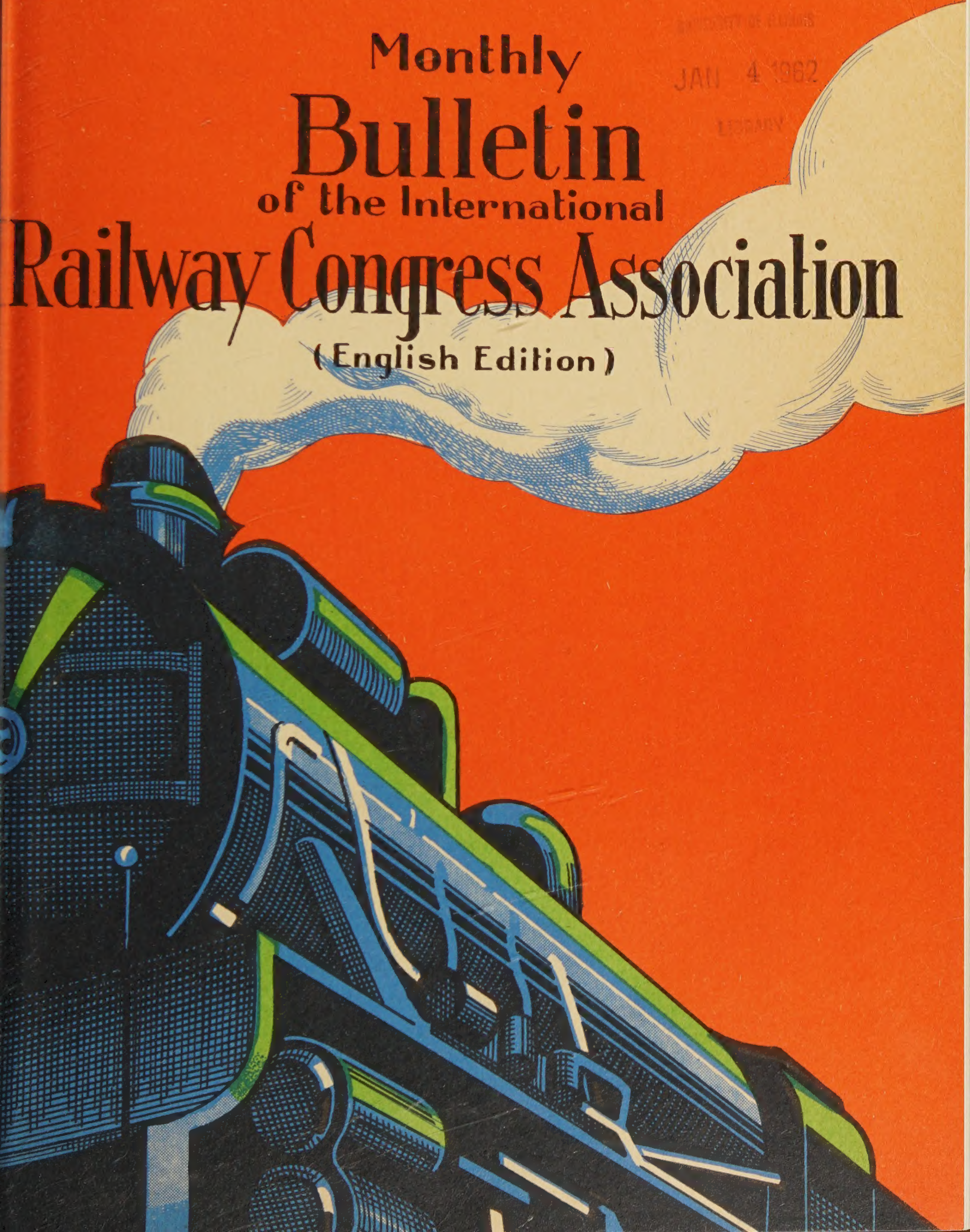
VOL. XXXVIII. — No. 11. NOVEMBER 1961.

Monthly Bulletin of the International Railway Congress Association

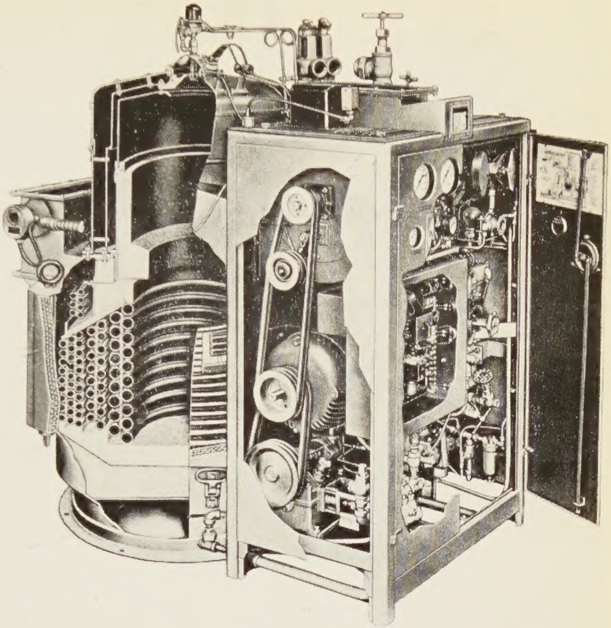
(English Edition)



Alphabetical Index of Advertisers

VAPOR PRODUCTS

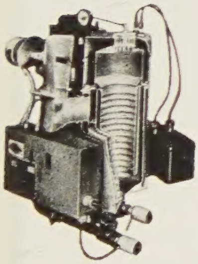
serving railroads over hundreds of millions of miles



Your attention is directed to the record of VAPOR products — in railroad service for over fifty years. Now used in 25 countries in Europe and over the world, VAPOR equipment includes all components of the steam or hot water heating system — from heat source, through regulators, radiation, valves, and thermostatic controls. Also, where electric heat is necessary, VAPOR Control Systems have found wide use with most satisfactory results.

The VAPOR model OK steam generator is sectionally illustrated here to show you its sturdy construction. The unit is robust, reliable, and compact — with exceptionally high output per unit of weight, on axles. Vital statistics of OK-4616 : sustained output — 750 kg/h; operating weight — 1,350 kg; overall dimensions — 165 × 110 × 160 cm. Similar models available with outputs ranging from 225 to 2,000 kg/h.

The VAPOR Thermostat shown here is just one in the hundreds of model and voltage designations now controlling railroad heating systems and air conditioning. VAPOR temperature controls are characterized by accurate performance and simple maintenance. They flatten the curve of temperature variation to within one degree centigrade, and all are manufactured to rigorous standards on exclusively patented production equipment.



EQUIPMENT MADE IN HOLLAND

Also illustrated in section — the compact VAPOR 4915-6 Circulating Water Heater (approx. 115 kg and 70 × 40 × 48 cm, with 32,000 kg Cal/h output). Widely utilized in heating systems on diesel railcars, and on diesel locomotives to automatically maintain full operating temperature of the engine coolant liquid. This of course assures full operating efficiency of the diesel, and eliminates the need for wasteful idling while on siding waiting for load.

Also available for lower heat output requirement the highly efficient B. 70 heater with a capacity of 16,000 kg Cal.

You are cordially invited to send for complete information. Please write to

VAPOR INTERNATIONAL CORPORATION, LTD.

224, SOUTH MICHIGAN AVENUE CHICAGO 4, ILLINOIS, U.S.A.

or for the equipment made in Holland to

VAPOR INTERNATIONAL CORPORATION, HOLLAND N.V.

BREUKELEN — HOLLAND

COCKERILL - OUGREE CONTRIBUTES TO THE MODERNIZATION OF RAILWAYS

With its complete line of diesel-electric locomotives ranging from 600 to 2000 HP, built under licence from Baldwin-Lima-Hamilton Corporation, specially engineered for passenger and freight service, COCKERILL-OUGREE has within its wide programme the precise unit which will perform economically and reliably any specific job under any conditions of climate and terrain.

Cockerill-Ougrée has also specialized in the production of diesel-hydraulic locomotives ranging from 200 to 800 HP

COCKERILL-OUGREE

SERAING (Belgium)

C 11/394

MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 19, RUE DU BEAU-SITE, BRUSSELS

Price of this single copy : 80 Belgian Francs (not including postage).

Subscription for 1961	**Belgium**	**700 Belgian Francs**
	Universal Postal Union . . .	**800 Belgian Francs**

Subscriptions and orders for single copies to be addressed to the General Secretary, International Railway Congress Association, 19, rue du Beau-Site, Brussels (Belgium).

Advertisements : All communications should be addressed to the Association, **19, rue du Beau-Site, Brussels (Telephone No. 47.53.35).**

CONTENTS OF THE NUMBER FOR NOVEMBER 1961.

CONTENTS	Page.

CONTENTS *(continued)*.	Page.

LIBRARY

OF THE

Permanent Commission of the International Railway Congress Association

READING ROOM : 19, rue du Beau-Site, Brussels.

Works in connection with railway matters, which are presented to the Permanent Commission are mentioned in the « Bulletin ». They are filed and placed in the library. If the Executive Committee deems it advisable they are made the subject of a special notice. Books and publications placed in the reading room may be consulted by any person in possession of an introduction delivered by a member of the Association.

Books, etc., may not be taken away except by special permission of the Executive Committee.

An edition in French is also published.

Vol. XXXVIII. — No. 11. November 1961.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .222 .5 (493)]

Calculation by computer of timetables for Diesel traction,(*)

by H. Laurent,

Ingénieur à la Direction du Matériel et des Achats de la Société Nationale des Chemins de fer Belges,

and R. Hautenauve,

Dirigeant du Bureau des Etudes de l'ordinateur de la Société Nationale des Chemins de fer Belges.

The departments of the Belgian National Railways (S.N.C.B.) have developed a method, based on the use of punched cards and computers, of calculating timetables for Diesel traction. The interest attached to such an application will be obvious to anyone. At the same time, however, the method would seem to provide a conclusive example for the potentialities of the new methods and for the flexibility with which these can be adapted to the requirements of a technical problem.

We hope that the publication of this method will help to enlighten the specialists in the various fields of railway activities about the new possibilities, often still ignored, offered by the computers.

The present account will not contain any technological information of a specialized nature. It should therefore not cause surprise that the computer will only rarely be discussed explicitly. In fact, the crux of the problem consists not so much in the working of the machine but rather in the rational *transposition* of the technical problem into one that can be tackled by computer techniques. Once this transposition has been achieved, the exposition of the first problem is synonymous with the exposition of the second.

In order to arrive at an efficient solution, it is necessary to establish active and close collaboration between the specialists in both spheres.

The following account provides a concrete example of a collaboration of this kind.

I. — TERMS OF THE PROBLEM

The problem consists in calculating :

a) the time required by a Diesel railcar or locomotive-hauled Diesel train to cover

(*) The calculation of timetables for electric traction will be dealt with in a separate study.

the distance between two given points of the railway network;

b) the times at which intermediate points are passed;

c) the speeds reached at these intermediate points.

The times thus determined are called « performances ».

II. — BASIC DATA

1) **Permanent data concerning the railway line.**

As the railway network is divided into a certain number of lines, the « line » unit is taken as basic unit of computation. In other words, the timetables are calculated by line, or by section of line.

Any point of a line can always be characterized by an up-grade, a down-grade or level track, by a curve radius or straight alignment, and by the maximum authorized running speed.

It is assumed that the curves give rise to an additional resistance :

$$r = \frac{750}{C}$$

where r is the resistance in kilograms per metric ton of train weight; and

C the curve radius in metres.

In practice, the influence of the curves and that of the profile (up-grade, down-grade, or level track) determine a single coefficient for each point of the line.

Examples :

a) an up-grade of 3.2 mm/m and a curve of 1 250 m radius give rise to an equivalent up-grade of $3.2 + \frac{750}{1\,250} = 3.8$ mm/m;

b) a level track and a curve of 1 500 m radius give rise to an equivalent up-grade of $0 + \frac{750}{1\,500} = 0.5$ mm/m;

c) a down-grade of 5.6 mm/m and a curve of 500 m radius give rise to an equivalent down-grade of $5.6 - \frac{750}{500} = 4.1$ mm/m.

The line is divided into a certain number of sections, where each section has the same authorized maximum speed and the same combined coefficient of profile and curvature.

A station or any other special point along the line is regarded as the end of a section.

The punched card system comprises, as a permanent feature, a set of punched cards with basic data relating to all the lines of the network, with all the different routes, if any, which may be followed on the same line.

These cards contain the following data :

1) direction of running;
2) number of the line;
3) number of the route chosen on this line (either between two stations, or within a station, depending on the lay-out concerned);
4) number of the section;
5) maximum speed authorized on this section, in km/h;
6) the kilometric position (expressed in kilometres and metres) of the end of the section (the number of the first section not being 01 but 00 so that the commencement of section 01 can also be obtained);

7) the combined coefficient of profile and curvature;

8) the code of this combined coefficient, with 0 indicating a level track or down-grade;
(a curve coefficient must always be regarded as an up-grade); and
1 indicating an up-grade;

9) the name of the station, in plain language.

These basic data are communicated to the Punched Cards Section by the Rolling Stock and Traction Department(1) of the S.N.C.B. who, for this purpose, use the document Sp 1/M.A. 22-3 (Appendix I).

Any subsequent modification to the basic features of the line (speed limit, curvature, profile) must be recorded on a new document Sp 1/M.A. 22-3 which supersedes the earlier one.

These data serve for the preparation of the set of basic data cards of the Punched Cards Section which is thus in possession of exact information concerning all lines of the network.

2) **Data specific to the required timetable.**

The calculation of a specific timetable obviously calls for further information, especially :

— the type of run (through train, semi-fast train, stopping train), i.e. the points along the line where it is desired either to book the train to stop or to know the passing time;

— the weight of the locomotive;

— the weight of the train set;

— the maximum speed of the locomotive;

— the type of locomotive (and therefore its tractive effort/speed characteristic);

— the kilometrage from the departure point;

— the type of traction (two varieties for Diesel traction);

— the type of train set (corresponding to a given formula of running resistance);

— the coefficient of deceleration or braking.

This information is supplied by the Rolling Stock and Traction Department whenever it is desired to work out a timetable or a set of timetables. It is contained in document Sp 2/M.A. 22-3, « Calculation Instruction » (Appendix II).

A scrutiny of this document will show that the data contained in it are highly condensed.

The top part provides the identification data and the information specific to the train. The main part of the document merely shows those sections of the line concerned where it is desired either to book a train to depart or stop or to calculate the passing time.

The section code numbers to be recorded first are :

01 for the departure station,

10 for a passing time,

11 for an arrival time.

The document provides four columns for the indication of the arrival times at different stations. If these columns are not used, the figure zero is entered.

Normally, it is not necessary to take the length of the train into account. However, a corresponding space has been provided in the form, and the contingency has been covered in the programme.

(1) Called « Service du Matériel et des Achats » on the Belgian National Railways. (S.N.C.B.)

Example for using the form.

For a semi-fast passenger train from Brussels to Tournai (passing time at Hal, stops at Enghien, Bassilly, Ath, Leuze[1],) hauled by a Diesel locomotive T. 204 weighing 108 tons, the Rolling Stock and Traction Department wishes to know the different timmings for train weights of 200, 300, 400, 450 and 500 tons, respectively.

For this purpose, it is sufficient for the Rolling Stock and Traction Department to forward the document shown as Appendix III. The Punched Cards Department will then combine the data contained in this document with those of the set of basic data in their possession in order automatically to obtain the five timetables concerned.

III. — COMPUTATION WORK

The organisation of this work has been designed for the compilation of a *whole* set of timetables with the highest possible degree of automation while reducing the obligations of the Rolling Stock and Traction Department to a minimum.

As is shown schematically in Appendix IV, the computation work comprises three phases :

First phase. — Preparation of the work.

The computation of a given timetable calls for the combination of the basic data with those contained in the « Calculation Instruction » form. In certain cases, it may be necessary to reproduce a part of these data.

In the example referred to above, the request is for the computation of five different timetables for the same route from Brussels to Tournai. Since the Department has only one set of basic data available for this route, it is first of all necessary, in order to reduce the machine time, to reproduce five sets of identical cards. These cards contain, firstly, the identification data and the elements specific to the train and, secondly, the line characteristics conveniently arranged as regards the sections for which an arrival time or passing time is required.

All these operations are carried out automatically in bulk by means of the computer which also undertakes the preselection of the data required for the calculation.

Second phase. — Performance calculation.

a) *Sectionalisation of the line.*

As already indicated, each line is divided into a certain number of sections, each of which has certain characteristics. This sectionalisation, which merely takes the line features into account, is obviously theoretical and must be adapted to each specific timetable depending, especially, on the train stops required and on the braking distances resulting from them.

Moreover, the maximum speed authorized on a given section is not always the one which must be taken into account. This will apply to all cases where the maximum speed of the train is lower than the authorized maximum speed of the section; in this case, the maximum speed of the train is the only one to enter into the calculation.

---

(1) Hal = end of section 11;
Enghien = end of section 24;
Bassilly = end of section 30;
Ath = end of section 48;
Leuze = end of section 56;
Tournai = end of section 67.

Subsequently, by (as it were) running over the line in the *reverse direction*, the computer will carry out the following operations in a single phase :

1) replacing the authorized maximum speed by the maximum speed of the train wherever the latter is lower;

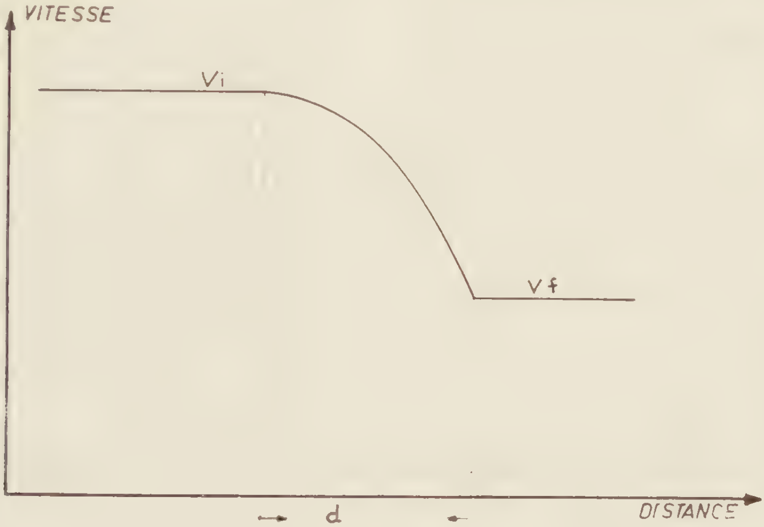
The deceleration is assumed to be constant over the whole of the braking period, and is calculated as follows :

on an up-grade or on the level :

$$a = a_0 + \frac{ig}{k}$$

on a down-grade:

$$a = a_0 - \frac{ig}{k}$$



N. B. — Vitesse = speed.

2) determining and locating the different braking sections required to cause the train to stop or to comply with a specific speed limit.

The braking distance is determined from the formula :

$$d = \frac{V_i^2 - V_f^2}{2a}$$

where :

d = braking distance in metres,

V_i = maximum speed at the commencement of the braking section (in m/s);

V_f = maximum speed at the end of the braking section, (in m/s);

a = the deceleration m/sec^2.

where :

a = the effective deceleration in m/sec^2;

a_0 = the deceleration coefficient (or deceleration on the level) in m/sec^2;

viz. 0.75 m/sec^2 for railcars;
0.50 m/sec^2 for locomotive-hauled trains :

i = the line profile expressed in the form of a decimal fraction, representing, in thousandths, the number of mm/m of the up-grade or down-grade (e.g., for an up-grade of 16 mm/m, i = 0.016);

g = the gravity acceleration, i.e. 9.81 m/sec^2;

k = the coefficient of inertia of the rotating masses, assumed to be 1.175.

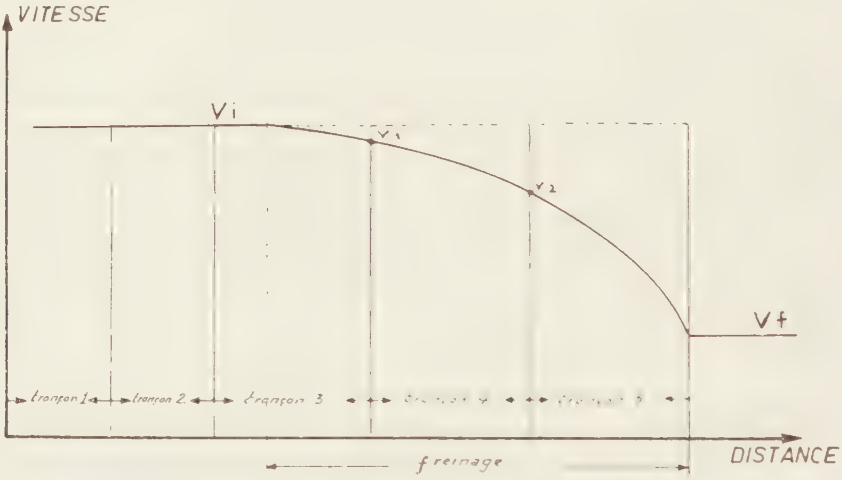
If V_i and V_f are given in km/h, these values must be divided by 3.6 in order to obtain the speeds in m/sec.

It should be noted that, where the braking distance exceeds the length of the section(s) preceding the train stopping point or the speed reduction point, a new speed (V_1, V_2 ...) is calculated for *each* of these sections as a function of the brake application required.

Thus, after the completion of all these operations, the computer has divided the line into a certain number of sections adapted to the requested timetable, each of them presenting the criteria permitting a direct calculation of the performance.

Example.

This sectionalisation is schematised in the graph hereafter.



N. B. — Vitesse = speed. Freinage = braking. — Tronçon = section.

This contains the following items, in the order shown here :

— the kilometric position of the ends of the sections, in metres;

— the numbers of the sections;

— the maximum speed authorized on each section;

— the profile of each section;

— the location of the stopping stations (end of sections 04, 05, 07, 08, 12, 13, 17);

— the braking distances;

— above the latter, for greater convenience, the kilometric position of the brake application points :

section 17: 112.097—0.607 = 111.490;

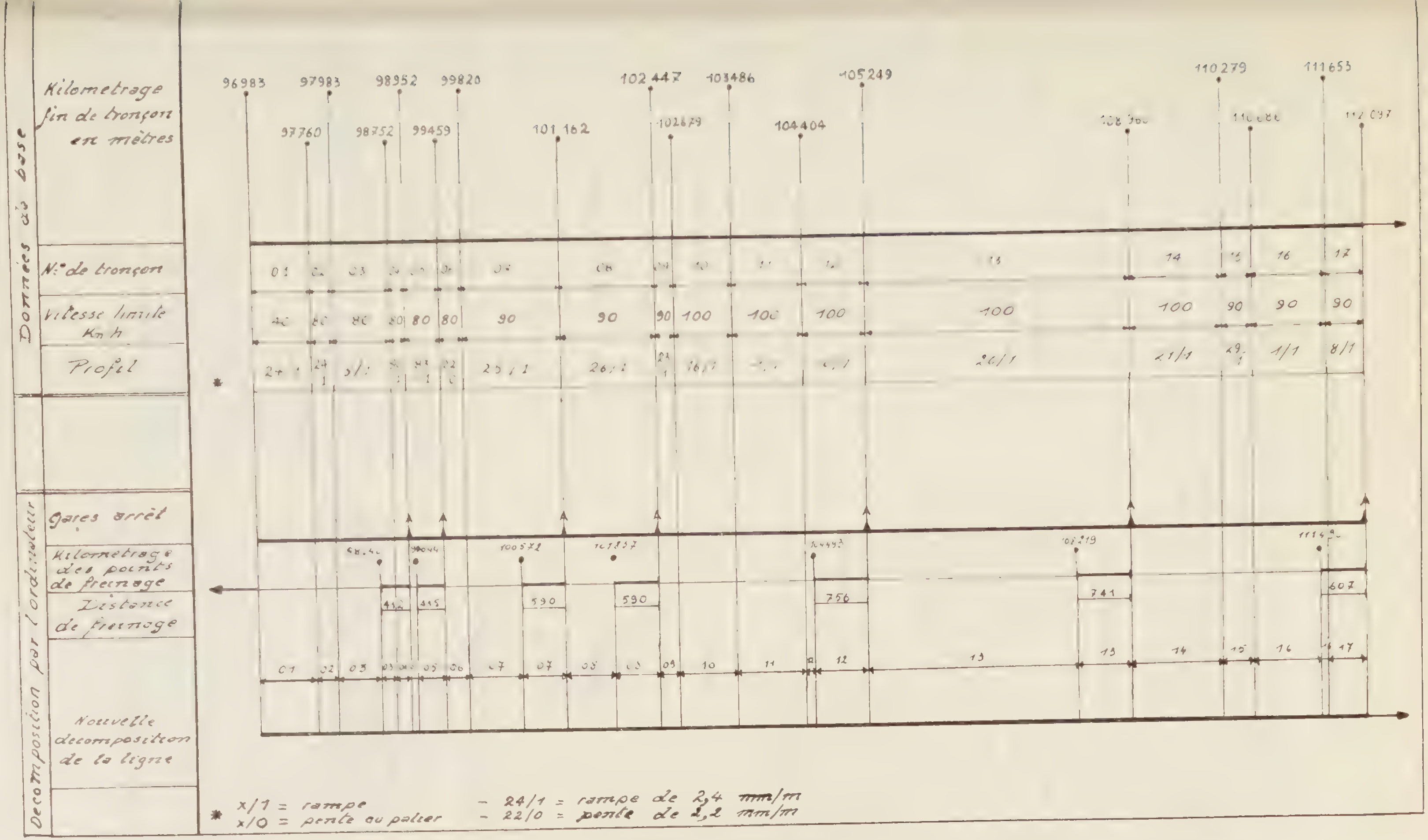
section 13: 108.960—0.741 = 108.219;

section 12: 105.249—0.756 = 104.493;

. . . .

section 4: 98.952—0.412 = 98.540.

In this last case, section 4 is entirely



Explanation of French wording.

Donnees de base = basic data. - Kilometrage fin de tronçon en mètres = kilometrage at the end of the section, in metres. — N° de tronçon = No of section. — Vitesse limite (km h) = maximum speed, in km/h. — Profil - profile. — Décomposition par l'ordinateur -- sub-division by computer. - Gares arrêt - stopping stations. — Kilomètrage des points de freinage = kilometrage of brake application points. — Distance de freinage — braking distance. – Nouvelle décomposition de la ligne -- new sub-division of the line. — x/1 — gradient. — 24/1 = up gradient of 2.4 mm/m. — x/0 -- down gradient or level track. — 22/0 = down gradient of 2.2 mm/m.

within the braking zone, and the brake application point is located in section 3,

— the new sectionalisation of the line where the latter is, this time, followed in the direction 01, 02, 03.

b) *Calculation of the running time.*

In order to obtain a fairly close approximation, the calculation of the acceleration and the resulting running time is carried out, on each section, by zones of 50 m length, called « integration steps ». At the start, the first two integration steps are reduced to 25 m.

In fact, the computer, in analyzing at each « integration step » the movement of the train running over the line, carries out a whole sequence of operations which can be characterized as follows :

1) **Calculation of the train resistance.**

The rolling resistance of the train on level track is calculated as follows :

— for a locomotive-hauled train :

$$R(A) = \left[2 + \frac{1}{40}\left(\frac{V}{10}\right)^2\right] P + \left[3 + \frac{1}{20}\left(\frac{V}{10}\right)^2\right] L$$

where :

R (A) = the resistance force in kilograms;
V = the speed in km/h;
P = the trailing weight in metric tons;
L = the locomotive weight in metric tons;

— for a railcar :

$$R(A) = \left[2.5 + \frac{1}{30}\left(\frac{V}{10}\right)^2\right] Q$$

where :

R (A) = the resistance force in kilograms;
V = the speed in km/h;
Q = the weight of the railcar, in metric tons.

The total resistance is determined from the formula :

$$R = R(A) \pm i\,Q$$

where :

R = the total resistance of the train, in kilograms;
R (A) = the rolling resistance on level track, in kilograms;
i = the combined coefficient taking into account the profile and curvature of the line, expressed as a number indicating the mm/m of the equivalent up-grade or down-grade;
Q = the train weight in metric tons.

The product $i\,Q$ is added in the case of an up-grade and subtracted in the case of a down-grade. On level track, this product is obviously zero.

2) **Calculation of the tractive effort at the wheel rim.**

To each locomotive speed corresponds a tractive effort at the wheel rim.

The relation between these two variables can be expressed either by formulas or by a table, showing for different speeds the corresponding values of tractive effort.

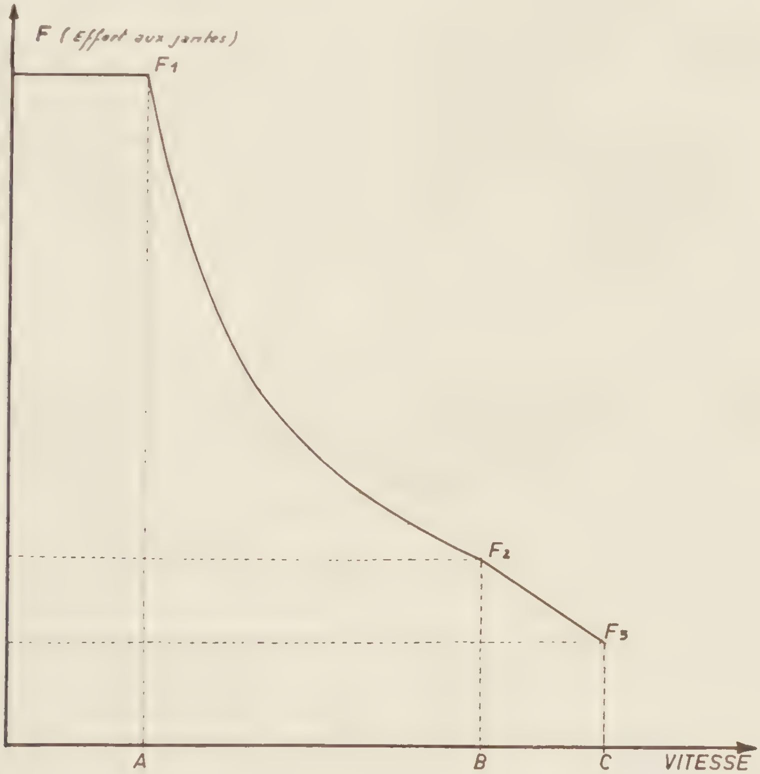
In the case of Diesel electric locomotives, for instance, the mean tractive effort characteristic can be reproduced as follows :

The curve is regarded as consisting of three sections, viz. :

1. A horizontal section where :

the tractive effort
F = constant.

Here the traction effort at the wheel rim is determined by the adhesion which is deliberately limited to a moderate value corresponding to normal operating conditions.



N. B. — Effort aux jantes = tractive force at wheel rim. — Vitesse = speed.

2. A hyperbolic section where the power is reasonably constant (apart from the variations in the efficiency of the transmission), i.e.

$$\underset{\text{(force)}}{F} \times \underset{\text{(speed)}}{V} = \text{constant.}$$

3. *Sometimes*, a third section consisting, near enough, of an inclined straight line detaching itself from the hyperbolic curve and reaching the abscissa of the maximum speed at an ordinate smaller than that of the constant power hyperbola. This case occurs when the main generator is no longer able to absorb the whole power of the Diesel engine and is said to « discharge ». In this case, the relation between F (force) and V (speed) is of the form :

$$F - F_B = \frac{F_B - F_C}{V_B - V_C} (V - V_B),$$

where the indices B and C relate to the respective B and C points on the curve.

The curve showing the tractive effort at

the wheel rim as a function of speed and, consequently, the different constants to be used in the formulas quoted above, vary with the type of locomotive concerned.

The computer storage device contains, in fact, a whole collection of formulas for the tractive effort, and the computer selects automatically the formulas to be used for the type of locomotive concerned.

Note : The computer programme does not concern itself with the effective current nor with the temperature rise in the drives, whether electric or hydraulic.

3) **Calculation of the acceleration.**

The acceleration is determined from the formula :

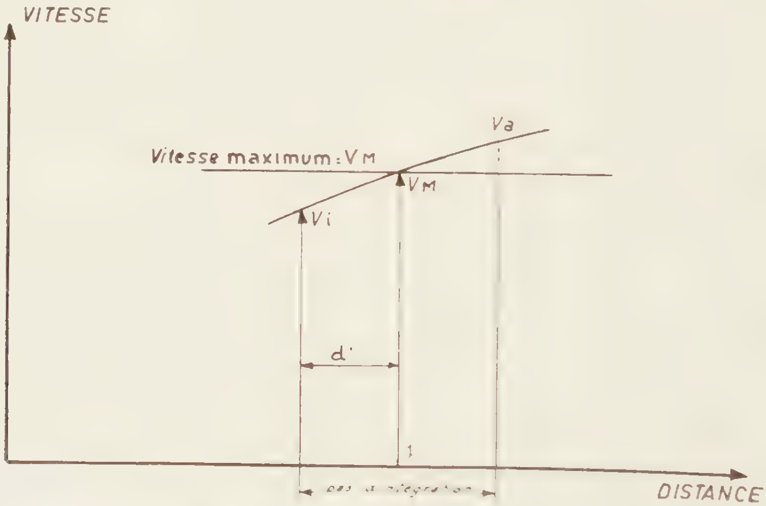
$$\gamma = \frac{g}{1\,000\,k}\left(\frac{F - R}{Q}\right)$$

where :

γ = the acceleration in m/sec^2;

k = the coefficient of inertia of the rotating masses, assumed to be equal to 1.175;

g = the gravity acceleration, i.e. 9.81 m/sec^2:



N. B. — Vitesse = speed. — Vitesse maximum maximum speed. — Pas d'intégration = integration step.

The S.N.C.B. Diesel locomotives are designed for mixed service at a relatively low speed (20 to 25 km/h), while the railcars are designed to provide a stopping service on some of the most difficult lines in the country.

As the question of overheating does not arise, it was unnecessary to complicate and overburden the programme with this problem.

F = the tractive effort at the wheel rim, in kilograms;

R = the train resistance in kilograms;

Q = the weight of the train in metric tons.

This acceleration may be positive or negative.

4) **Calculation of the speed at the end of the integration step.**

$$V^2_f = V^2_i + 2\,\gamma d$$

where :

V_f = the speed at the end of the « integration step » (in m/sec);

V_i = the speed at the end of the preceding « integration step » (in m/sec);

γ = the acceleration in m/sec²;

d = the length of the integration step (25 m or 50 m).

5) **Calculation of distance and time at the end of the integration step.**

The distance covered is totalized whilst the running time is determined from the formula :

$$\Delta t = \frac{2d}{V_i + V_f}$$

where :

Δt = the time in seconds;

d = the length of the « integration step » (25 m or 50 m);

V_i = the speed in m/sec, at the end of the preceding « integration step »;

V_f = the speed, in m/sec, at the end of the « integration step » considered.

In fact, all these operations concerned with the analysis of an « integration step » do not present any special features and therefore represent a normal type of calculation.

But a practical test will rapidly show that conditions in practice are more variegated and that special features must be taken into account in the calculation. Experience has shown that various special contingencies must be provided for and that the computer must, during the logical process of computation, be able to recognize these cases and to deal with them. As soon as a special feature is detected, the calculation is diverted to the appropriate channel where, in each case, the point of return to the main channel of calculation is determined beforehand.

As far as the special features are concerned, it is necessary, in particular, to take into account :

a) the special case where, in an « integration step » the authorized maximum speed is reached :

In this case, the computer works out the point at which the « acceleration curve » and the « maximum speed curve » intersect.

The « acceleration curve » is given by the above-mentioned formula :

$$V^2_f = V^2_i + 2\,\gamma d$$

where V_f now becomes V_M (maximum speed), whilst d becomes the unknown variable d', smaller than the length of the integration step, so that :

$$V^2_M = V^2_i + 2\,\gamma d'$$

or

$$d' = \frac{V^2_M - V^2_i}{2\gamma}$$

The time t' required to cover this distance is

$$t' = \frac{d'}{\frac{V_i + V_M}{2}}$$

or

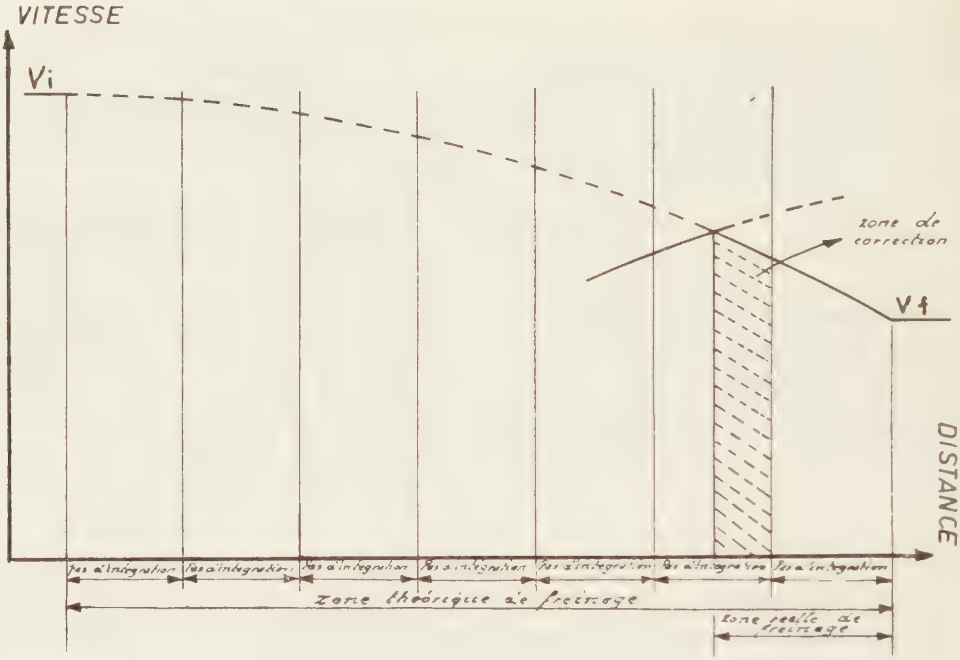
$$t' = \frac{2d'}{V_i + V_M}$$

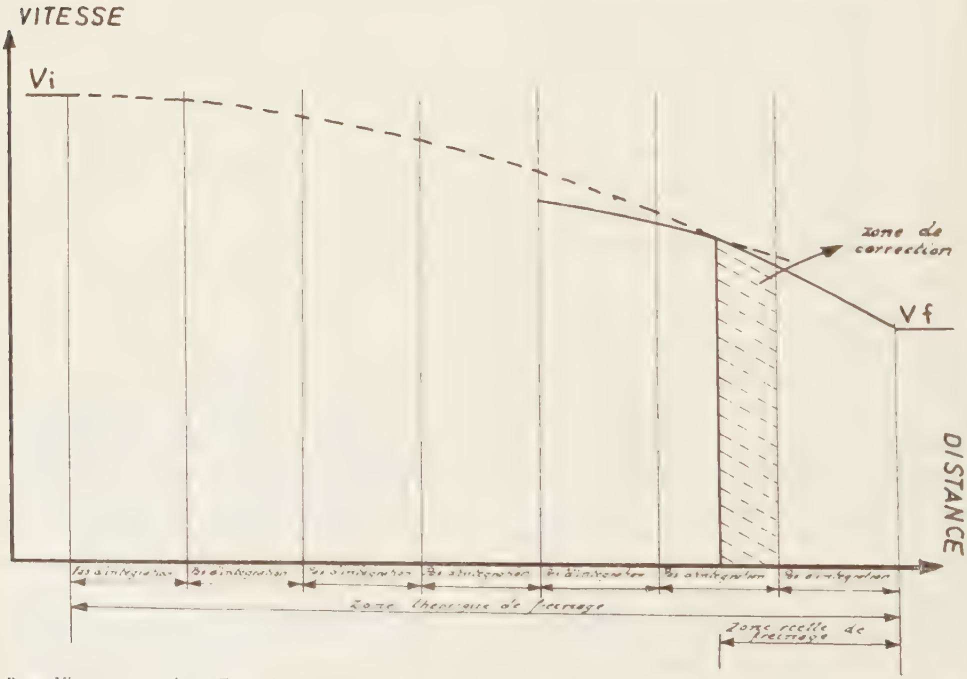
where the units of measurement are, as usual, metres and seconds.

Once this point is determined, the computer works out directly the time and distance for the remainder of the section concerned.

b) the braking zones.

The braking zones have already been





N. B. — Vitesse = speed. — Zone théorétique de freinage = theoretical braking zone. — Zone réelle de freinage = actual braking zone. — Pas d'intégration = integration step.

determined and located in the first sequence of computer operations. Their calculations are based on the authorized maximum speeds so that they represent theoretical values.

Therefore, when a brake application point is approached, the computer proceeds to analyze the following possibilities:

— if the brake application point is approached at the authorized maximum speed, the braking distance previously worked out is correct, and the calculation proceeds as planned;

— if the brake application point is approached with a speed lower than the authorized maximum speed, the computer calculates the point at which the « acceleration » or « deceleration » curve and the « braking » curve intersect.

In fact, at each « integration step » comprised in the theoretical braking zone, the computer probes whether the intersection point is situated in the « integration step » concerned. It is only if the answer is in the affirmative that the necessary corrections are carried out as regards speed, time and distance.

Finally, it may be of interest to note that, as the calculation progresses, the computer initiates simultaneously the recapitulation of the different units (passing time, arrival time, distances, speeds attained, etc.). These units, when totalized, synthesized and if necessary converted, yield the detailed results of the performance calculation.

By way of example, this working process has been illustrated in Appendix V which shows, in a schematic form, the structure of the operations to be undertaken.

Third phase. — Compilation of standard timetables.

In order to permit an analysis of standard timetables, the performance has been calculated at a sufficiently low level, viz. that of the actual section of line. In practice, however, this assembly of details is not often desired, and it is generally preferred to have a synopsis of the strictly necessary data, arranged so as merely to show the stopping and passing points required.

For that reason, the computer is made to carry out yet another recapitulation which is, this time, confined to the level of the points referred to above (i.e. stepping and passing points).

The running times thus calculated are theoretical but can often not be realized in practice, for a number of reasons. Two, of these reasons may be quoted here :

— It is, generally not possible, even if this is assumed in the calculation, strictly to adhere to the maximum speed of the line. The run takes place between two speeds which are the more close to each other, the more perfect the locomotive controls. A similar consideration applies to steep down-grade where braking is necessary.

— The speed indicator is set for wheel tyres of mean thickness. If the tyres are new (and therefore thicker), the speed indicator will show too low a speed. But if the tyres are nearly worn out, the indicator will show the maximum speed before it is, in fact, reached by the locomotive.

In view of this fact, the computer programme makes provision for the possibility of increasing the running times by a certain percentage.

As a running time indication in minutes and seconds is not easy to use, the computer will show round minutes and half-minutes in accordance with a predetermined rule.

Finally, the results are shown as exemplified in Appendix VI, viz. :

a) the calculated performances, expressed in minutes and seconds;

b) the same times, increased by a certain percentage and rounded to minutes and half-minutes.

IV. — COMPUTER PERFORMANCE TIME

The time required by the computer for the calculation of different specific timetables may vary greatly and is apt to show considerable differences. The time is in fact dependent on a whole array of variables which may vary a good deal; in particular :

— the length of the line;

— the profile of the line;

— the type of locomotive;

— the trailing load;

— the type of timetable demanded, etc.

The table below, which comprises some typical cases among those for which calculations have been carried out so far, shows the mean time to vary between 2″ and 18″ per kilometre of line.

Line	Type of timetable	Load hauled in tons	Type of locomotive	Calculation time per km of line
Brussels to Ostend	through train	100	212	2 .
Brussels to Ostend	through train	200	212	2 .7
Tournai to Brussels. . . .	through train	100	204	5 .
Tournai to Brussels. . . .	through train	300	204	13 .
Brussels to Ostend	semi-fast train	100	212	3 .5
Tournai to Brussels. . .	semi-fast train	100	204	7 .5
	semi-fast train	200	204	10 .
	semi-fast train	300	204	14 .-
	semi-fast train	400	204	15 .4
	semi-fast train	450	204	16 .-
	semi-fast train	500	204	18 .
Dendermonde to Brussels .	stopping train	200	204	16 .–
Dendermonde to Brussels .	stopping train	450	204	17 .2

APPENDIXES.

Sp. 1/M.A. 22-3.

B

CALCUL DES HORAIRES — BEREKENING DER UURROOST

« Renseignements relatifs à la ligne — Inlichtingen met betrekking tot de lij

SENS DU PARCOURS / RICHTING: 1

N° LIGNE / LIJN N°: 2 3 4 5

ITINERAIRE / REISWEG: 6 7

N° du tronçon / N° van het baanvak	Vitesse limite sur le tronçon km/h / Snelheidsgrens op het baanvak km/u	Kilométrage fin de tronçon (m) / Km. afstand aan het baanvakeinde (m)	Profil du tronçon / Profiel van het baanvak	Code profil-Code profiel	DESIGNATION DE LA GARE / AANDUIDING VAN HET STATION
8 9	10 11 12	13 14 15 16 17 18	19 20 21	22	61 — 80

Explanation of French wording.

Calcul des horaires = timetable calculation. — Renseignements relatifs à la ligne = data relating to the line. — Sens du parcours = direction c running. — N° ligne = No. of line. — Itinéraire = route. — N° du tronçon = No. of section. — Vitesse limite sur le tronçon km/h = maximu speed on the section km/h. — Kilométrage fin de tronçon (m) = kilometrage at the end of the section (m). — Profil du tronçon = section profile. - Code profil = profile code. — Désignation de la gare = name of station. — Nombre d'inscriptions valables = number of valid inscription

2/M.A. 22-3.

(B)

BEREKENING DER UURROOSTERS — CALCUL DES HORAIRES

« Berekeningsaanvraag — Demande de calcul »

Lijstnummer N° bordereau	Bewerk. - Opérations Code	Richting - Sens de parc.	LIJN - LIGNE Nummer Numéro	Reisweg Itinéraire	Snelheidsgrens HL (Km/u) Vitesse limite HL (Km/h)	Coëfficient a Coefficient	Gewicht HL (T) Poids HL (T)	Gewicht stel (T) Poids rame (T)	Verbeterde lengte van de trein Longueur corrigée du train	Afstand van het vertrekpunt (meter) Kilométrage du point de départ (mètres)	Code Tractie - Traction	Stel - Rame	HL type Type d'HL
1 2 3	4	5	6 7 8 9	10 11	12 13 14	15 16	17 18 19	20 21 22 23	24 25 26	27 28 29 30 31 32	33	34	35 36 37
	1												
	2												
	3												
	4												
	5												

Wachttijd (sec) Temps d'attente (sec)	Code Rit - Temps de parc.	Stilstand - Arrêt		N° baanvak N° tronçon	Wachttijd (sec) Temps d'attente (sec)	Code Rit - Temps de parc.	Stilstand - Arrêt		N° baanvak N° tronçon	Wachttijd (sec) Temps d'attente (sec)	Code Rit - Temps de parc.	Stilstand - Arrêt		N° baanvak N° tronçon	Wachttijd (sec) Temps d'attente (sec)	Code Rit - Temps de parc.	Stilstand - Arrêt		N° baanvak N° tronçon	Wachttijd (sec) Temps d'attente (sec)	Code Rit - Temps de parc.	Stilstand - Arrêt	Geldige inschrijvingen Inscriptions valables
0 41 42 43	44	45		38 39	40 41 42 43	44	45		38 39	40 41 42 43	44	45		38 39	40 41 42 43	44	45		38 39	40 41 42 43	44	45	
			1					21					41					61					81
			2					22					42					62					82
			3					23					43					63					83
			4					24					44					64					84
			5					25					45					65					85
			6					26					46					66					86
			7					27					47					67					87
			8					28					48					68					88
			9					29					49					69					89
			10					30					50					70					90
			11					31					51					71					91
			12					32					52					72					92

Explanation of French wording.

alcul des horaires = timetable calculation. — Demande de calcul = calculation instruction. — N° bordereau = list No. — Opération code = operation code. — Sens de parcours = direction of running. — Ligne = line. — Numero = No. — Itinéraire = route. — Vitesse limite HL (km/h) = locomotive maximum speed (km/h). — Coefficient a; = coefficient a;. — Poids HL (T) = locomotive weight (T). — Poids rame (T) = train set weight (T). — Longueur corrigée du train = corrected train length. — Kilométrage du point de départ (m) = kilometrage from the departure point (m). — Code = code. — Traction = traction. — Rame = train set. — Type d'HL = type of locomotive. — N° tronçon = No. of section. — Temps d'attente = waiting time. — Temps de parcours = running time. — Arrêt = stopping time. — Inscriptions valables = valid inscriptions.

Sp. 2/M.A. 22-3.

(B)

BEREKENING DER UURROOSTERS — CALCUL DES HORAIRES

« Berekeningsaanvraag — Demande de calcul »

Lijstnummer / N° bordereau	Bewerk. - Opération Code	Richting - Sens de parc.	LIJN - LIGNE: Nummer / Numéro	LIJN - LIGNE: Reisweg / Itinéraire	Snelheidsgrens HL (Km/u) / Vitesse limite HL (Km/h)	Coëfficient a / Coefficient a	Gewicht HL (T) / Poids HL (T)	Gewicht stel (T) / Poids rame (T)	Verbeterde lengte van de trein / Longueur corrigée du train	Afstand van het vertrekpunt (meter) / Kilométrage du point de départ (mètres)	Code: Tractie - Traction	Code: Stel - Rame	HL type / Type d'HL
1 2 3	4	5	6 7 8 9	10 11	12 13 14	15 16	17 18 19	20 21 22 23	24 25 26	27 28 29 30 31 32	33	34	35 36 37
001	1	1	0940	00	140	50	108	0200	000	000501	2	1	204
	2							0300					
	3							0400					
	4							0450					
	5							0500					

N° baanvak / N° tronçon	Wachttijd (sec) / Temps d'attente (sec)	Code: Rit - Temps de parc.	Code: Stilstand - Arrêt		N° baanvak / N° tronçon	Wachttijd (sec) / Temps d'attente (sec)	Code: Rit - Temps de parc	Code: Stilstand - Arrêt		N° baanvak / N° tronçon	Wachttijd (sec) / Temps d'attente (sec)	Code: Rit - Temps de parc	Code: Stilstand - Arrêt		N° baanvak / N° tronçon	Wachttijd (sec) / Temps d'attente (sec)	Code: Rit - Temps de parc	Code: Stilstand - Arrêt		N° baanvak / N° tronçon	Wachttijd (sec) / Temps d'attente (sec)	Code: Rit - Temps de parc
38 39	40 41 42 43	44	45		38 39	40 41 42 43	44	45		38 39	40 41 42 43	44	45		38 39	40 41 42 43	44	45		38 39	40 41 42 43	44
00	0000	0	1	1					21					41					61			
11	0000	1	0	2					22					42					62			
24	0000	1	1	3					23					43					63			
30	0000	1	1	4					24					44					64			
48	0000	1	1	5					25					45					65			
56	0000	1	1	6					26					46					66			
67	0000	1	1	7					27					47					67			
				8					28					48					68			
				9					29					49					69			
				10					30					50					70			
				11					31					51					71			
				12					32					52					72			

Explanation of French wording.

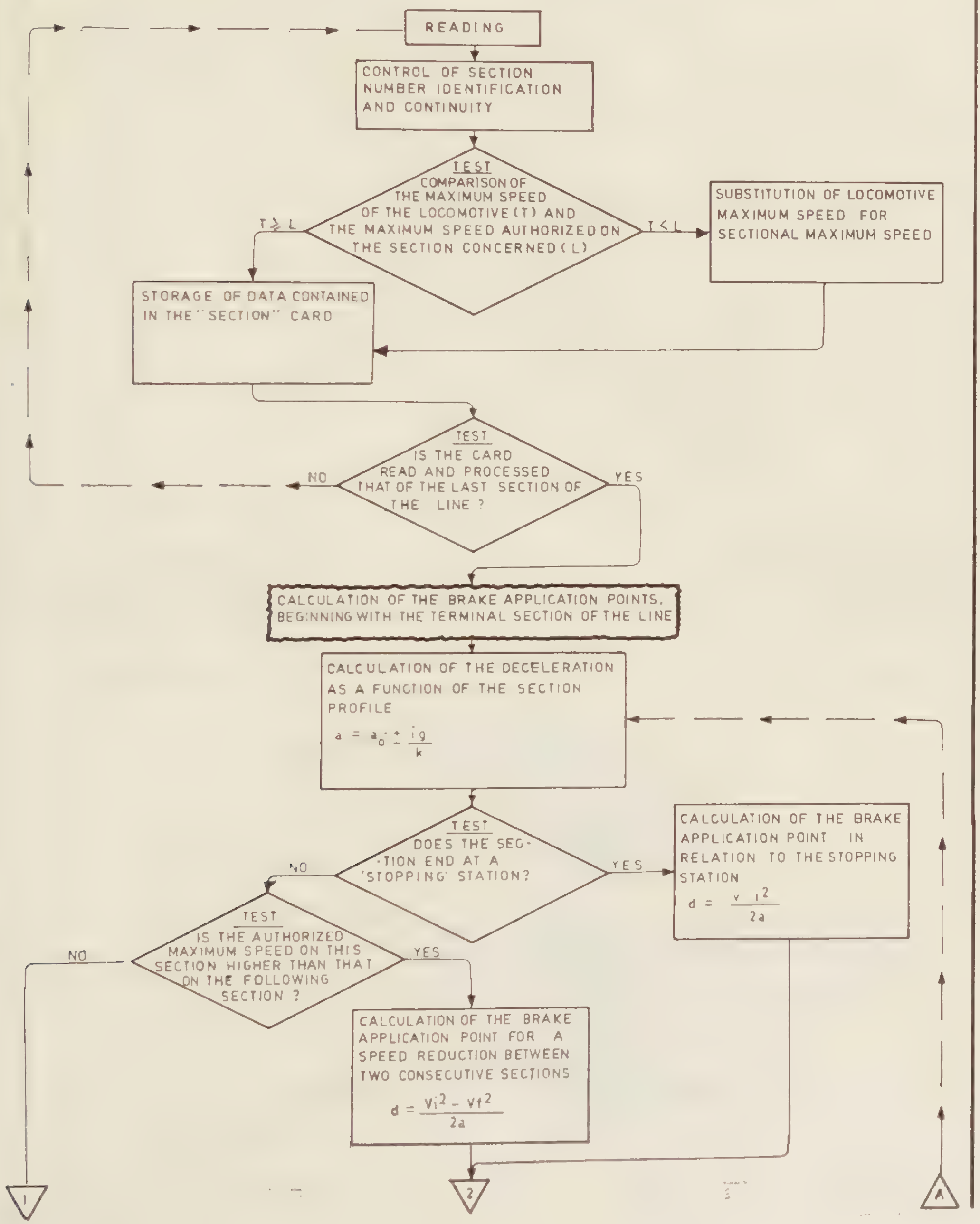
Calcul des horaires = timetable calculation. — Demande de calcul = calculation instruction. — N° bordereau = list No. — Opération code = operation code. — Sens de parcours = direction of running. — Ligne = line. — Numero = No. — Itineraire = route. — Vitesse limite HL (km/h) = locomotive maximum speed (km/h). — Coefficient a: = coefficient a: — Poids HL (T) = locomotive weight (T). — Poids rame (T) = train set weight (T). — Longueur corrigee du train = corrected train length. — Kilometrage du point de départ (m) = kilometrage from the departure point (m). — Code = code. — Traction = traction. — Rame = train set. — Type d'HL = type of locomotive. — N° tronçon = No. of section. Temps d'attente = waiting time. — Temps de parcours = running time. — Arrêt = stopping time. — Inscriptions valables = valid inscriptions.

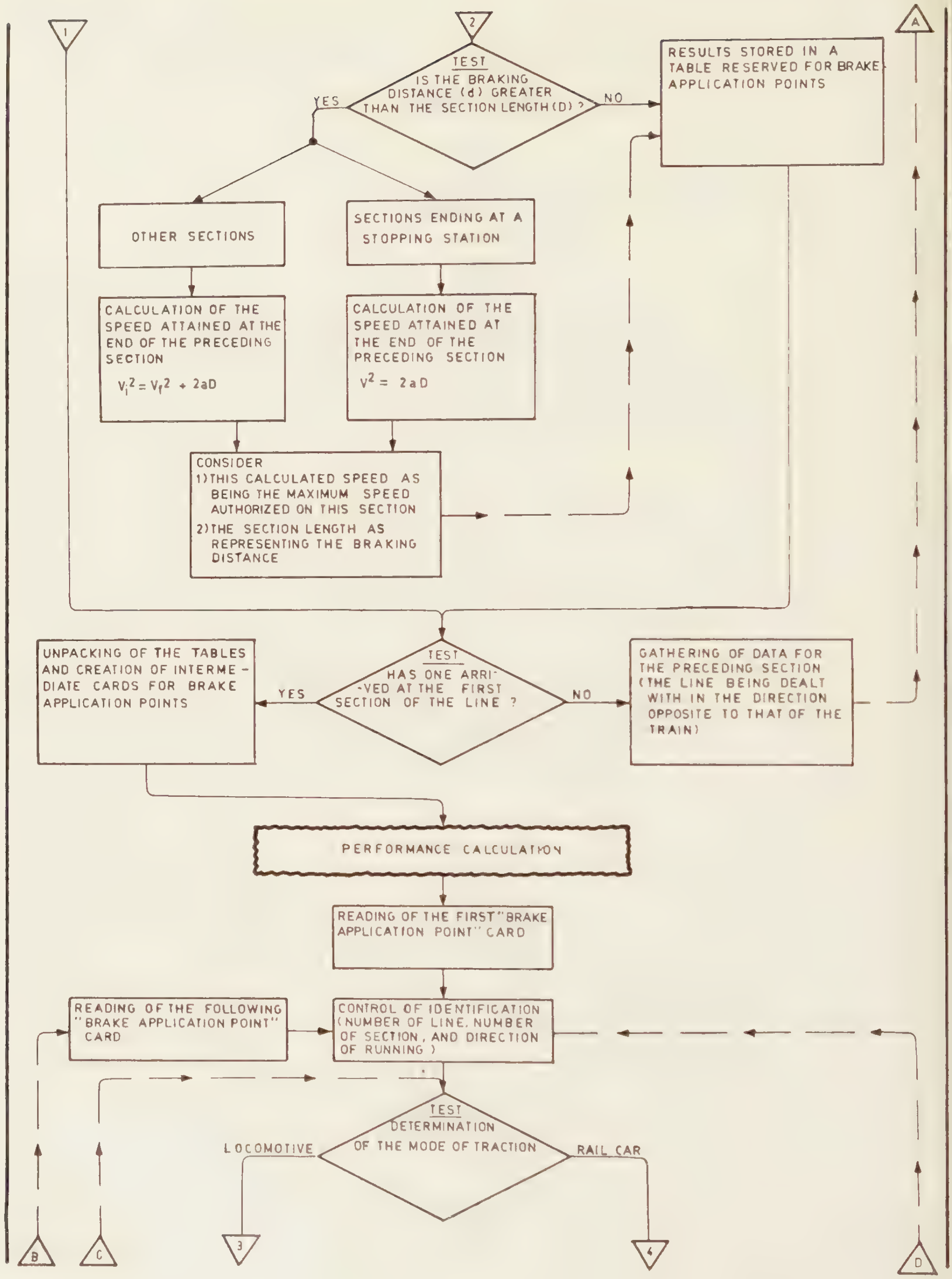
Specimen N° 1 - Li

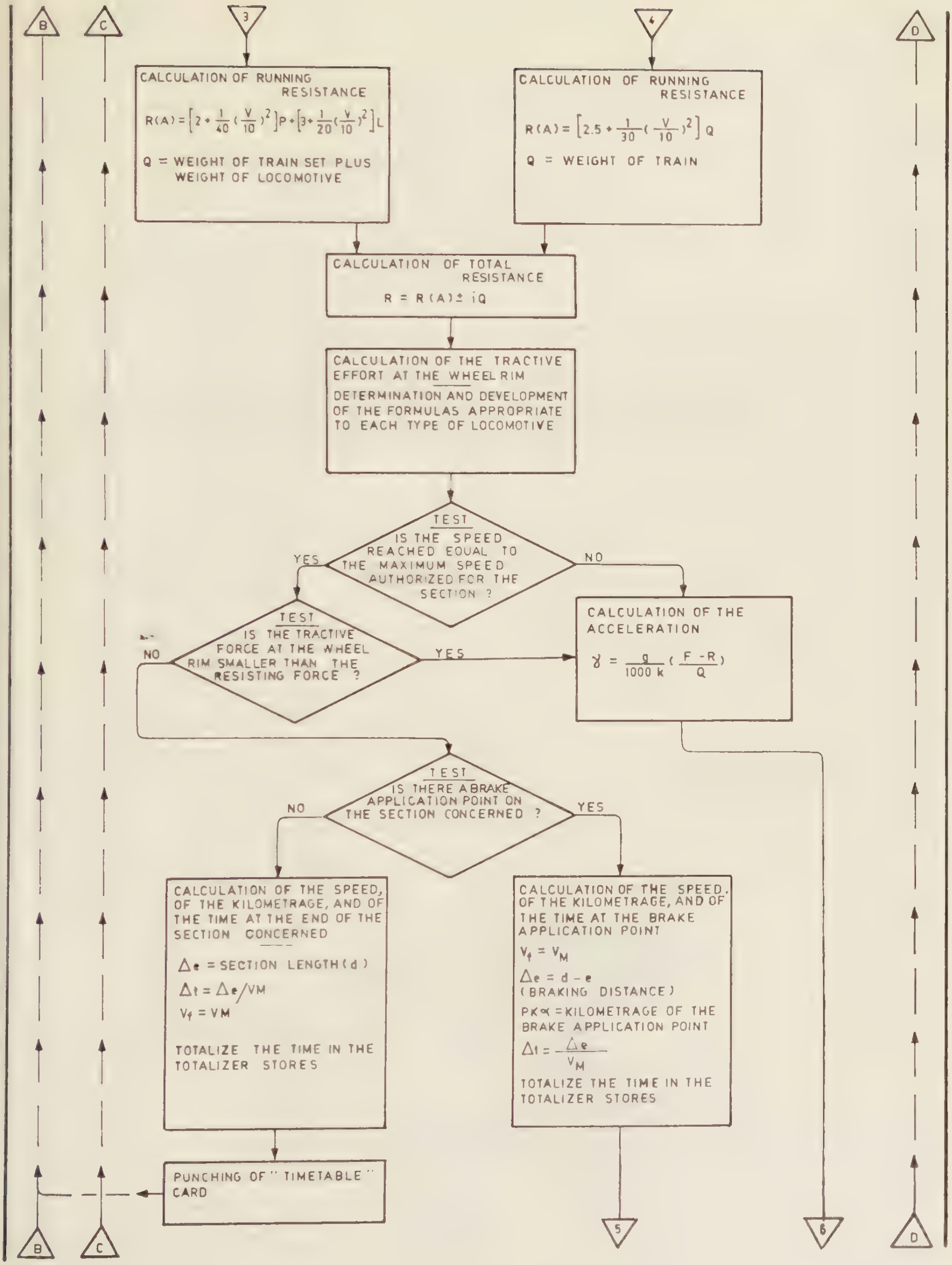
Direction of running	N° of line		N o se
	Line	Route	

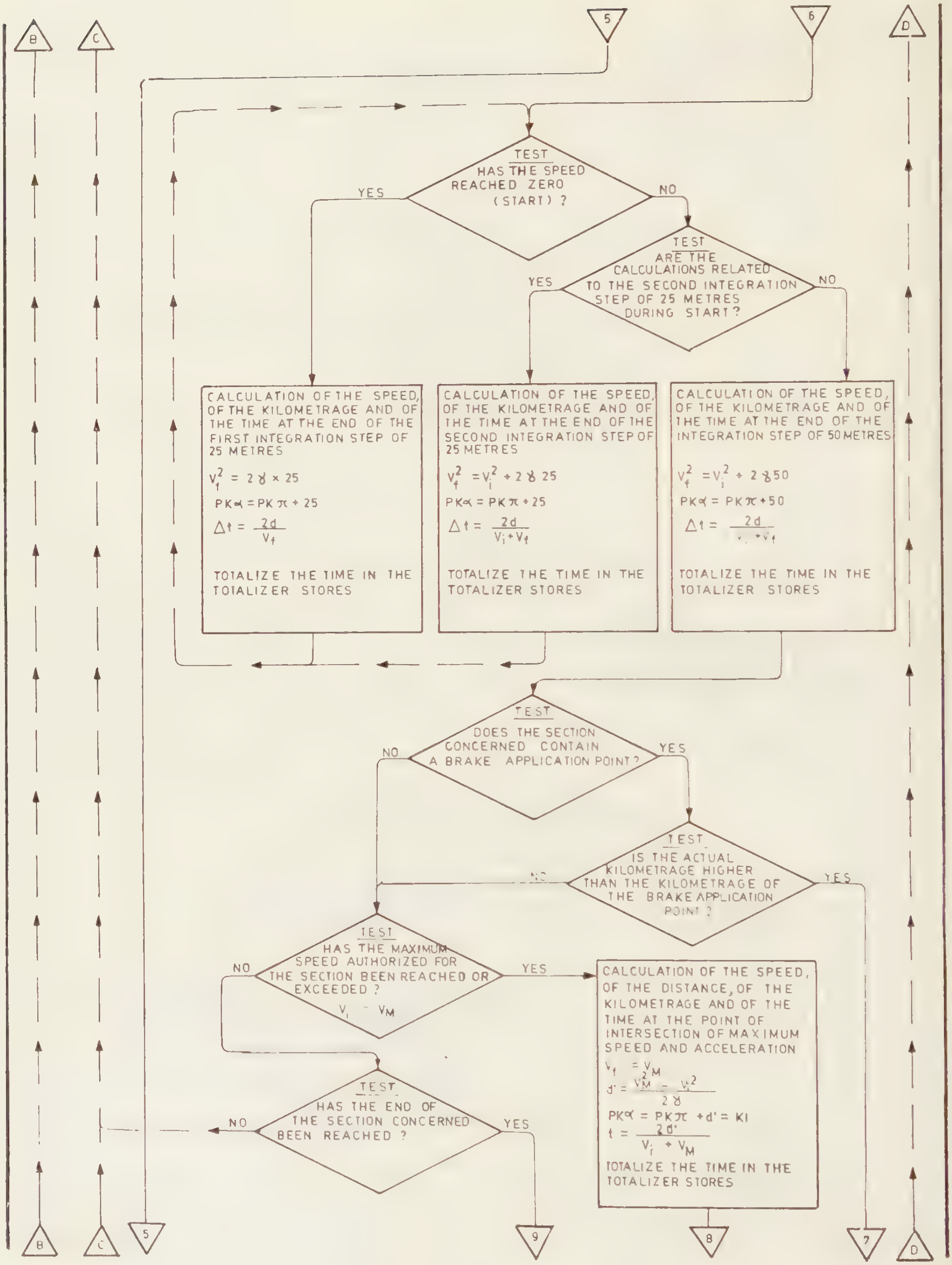
CALCULATION BY COMPUTER OF TIMETABLES FOR DIESEL TRACTION

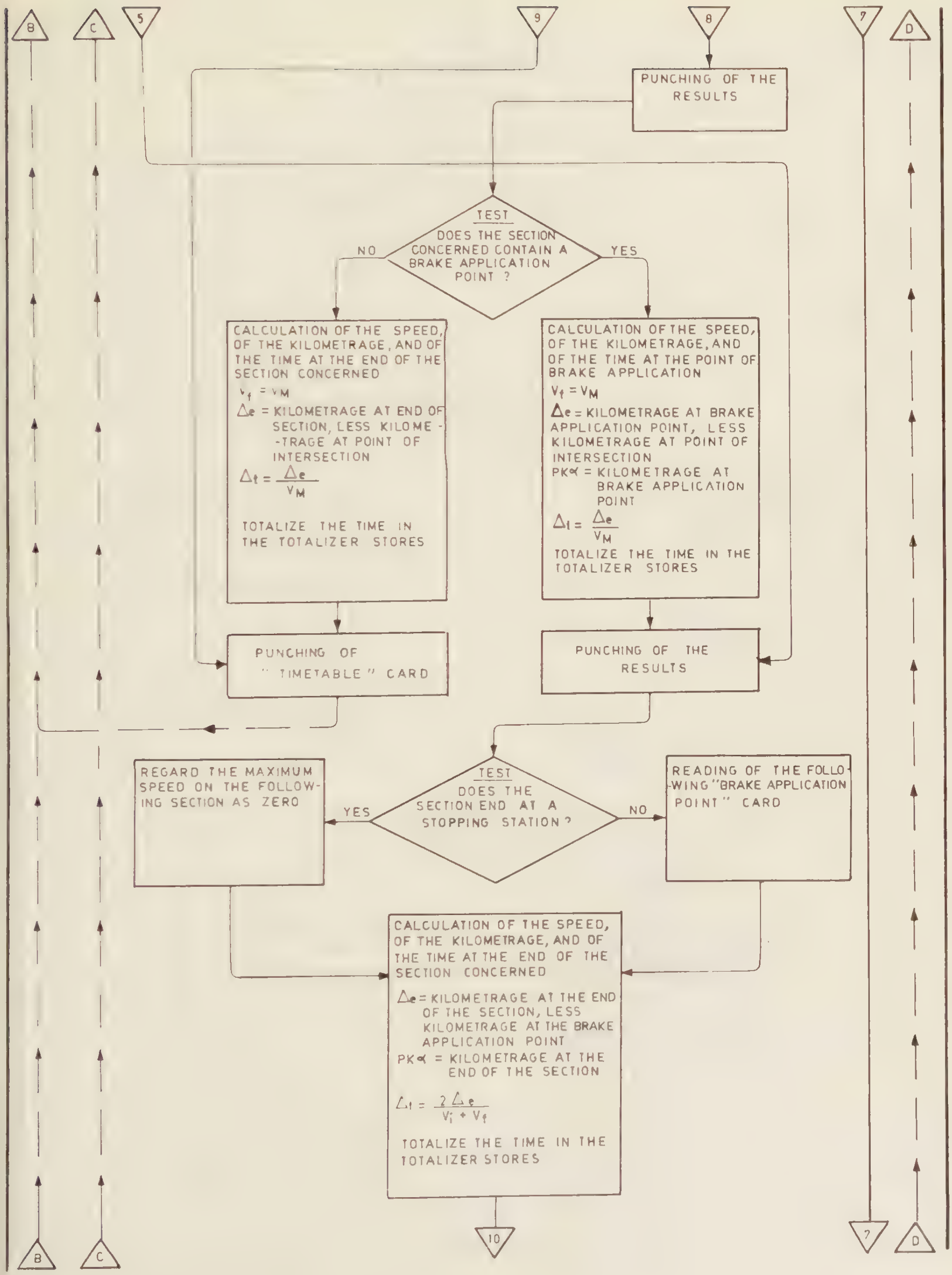
Flow Chart

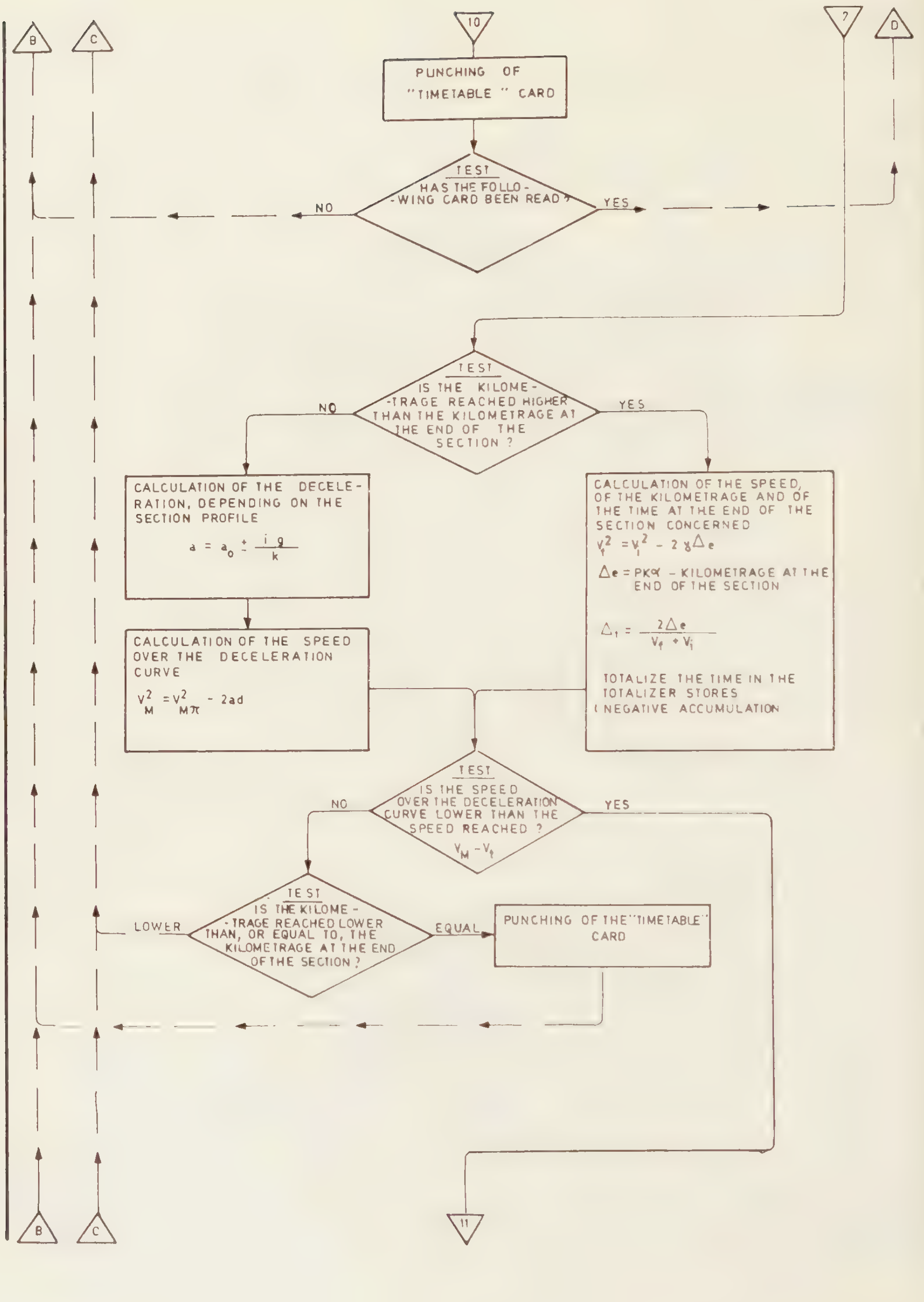



1
2
A
TEST
IS THE BRAKING DISTANCE (d) GREATER THAN THE SECTION LENGTH (D) ?
YES
NO
RESULTS STORED IN A TABLE RESERVED FOR BRAKE APPLICATION POINTS
OTHER SECTIONS
SECTIONS ENDING AT A STOPPING STATION
CALCULATION OF THE SPEED ATTAINED AT THE END OF THE PRECEDING SECTION
$V_i^2 = V_f^2 + 2aD$
CALCULATION OF THE SPEED ATTAINED AT THE END OF THE PRECEDING SECTION
$V^2 = 2aD$
CONSIDER
1) THIS CALCULATED SPEED AS BEING THE MAXIMUM SPEED AUTHORIZED ON THIS SECTION
2) THE SECTION LENGTH AS REPRESENTING THE BRAKING DISTANCE
UNPACKING OF THE TABLES AND CREATION OF INTERMEDIATE CARDS FOR BRAKE APPLICATION POINTS
YES
TEST
HAS ONE ARRIVED AT THE FIRST SECTION OF THE LINE ?
NO
GATHERING OF DATA FOR THE PRECEDING SECTION (THE LINE BEING DEALT WITH IN THE DIRECTION OPPOSITE TO THAT OF THE TRAIN)
PERFORMANCE CALCULATION
READING OF THE FIRST "BRAKE APPLICATION POINT" CARD
READING OF THE FOLLOWING "BRAKE APPLICATION POINT" CARD
CONTROL OF IDENTIFICATION (NUMBER OF LINE, NUMBER OF SECTION, AND DIRECTION OF RUNNING)
TEST
DETERMINATION OF THE MODE OF TRACTION
LOCOMOTIVE
RAIL CAR
B
C
3
4
D

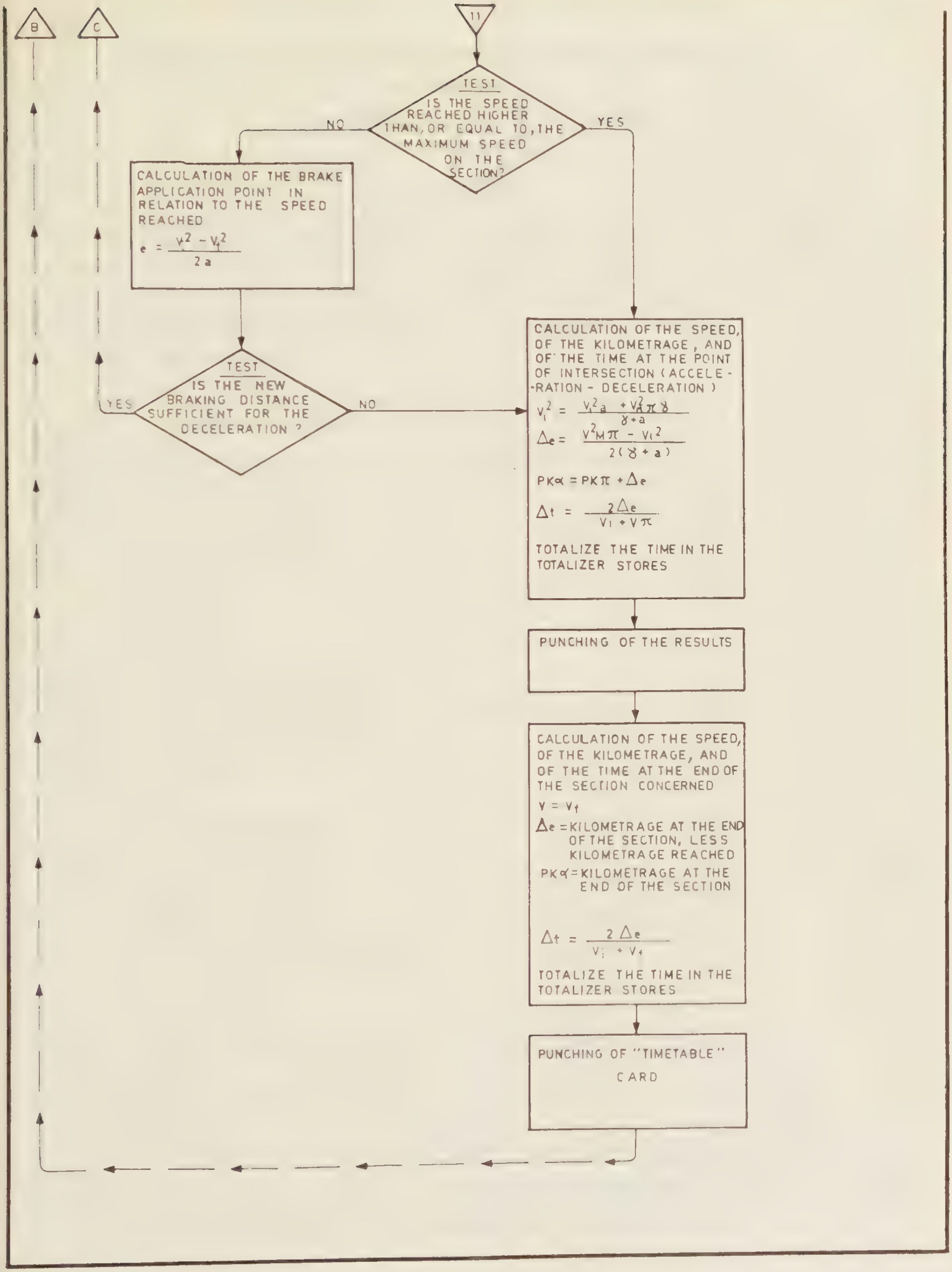

B
C
3
4
D
CALCULATION OF RUNNING RESISTANCE
R(A) = [2 + 1/40 (V/10)^2] P + [3 + 1/20 (V/10)^2] L
Q = WEIGHT OF TRAIN SET PLUS WEIGHT OF LOCOMOTIVE
CALCULATION OF RUNNING RESISTANCE
R(A) = [2.5 + 1/30 (V/10)^2] Q
Q = WEIGHT OF TRAIN
CALCULATION OF TOTAL RESISTANCE
R = R(A) ± iQ
CALCULATION OF THE TRACTIVE EFFORT AT THE WHEEL RIM
DETERMINATION AND DEVELOPMENT OF THE FORMULAS APPROPRIATE TO EACH TYPE OF LOCOMOTIVE
TEST
IS THE SPEED REACHED EQUAL TO THE MAXIMUM SPEED AUTHORIZED FOR THE SECTION ?
YES
NO
TEST
IS THE TRACTIVE FORCE AT THE WHEEL RIM SMALLER THAN THE RESISTING FORCE ?
NO
YES
CALCULATION OF THE ACCELERATION
γ = g/1000 k (F - R)/Q
TEST
IS THERE A BRAKE APPLICATION POINT ON THE SECTION CONCERNED ?
NO
YES
CALCULATION OF THE SPEED, OF THE KILOMETRAGE, AND OF THE TIME AT THE END OF THE SECTION CONCERNED
Δe = SECTION LENGTH (d)
Δt = Δe/VM
Vf = VM
TOTALIZE THE TIME IN THE TOTALIZER STORES
CALCULATION OF THE SPEED, OF THE KILOMETRAGE, AND OF THE TIME AT THE BRAKE APPLICATION POINT
Vf = VM
Δe = d − e
(BRAKING DISTANCE)
PKα = KILOMETRAGE OF THE BRAKE APPLICATION POINT
Δt = Δe/VM
TOTALIZE THE TIME IN THE TOTALIZER STORES
PUNCHING OF "TIMETABLE" CARD
B
C
5
6
D


B
C
5
6
D
TEST
HAS THE SPEED REACHED ZERO (START) ?
YES
NO
TEST
ARE THE CALCULATIONS RELATED TO THE SECOND INTEGRATION STEP OF 25 METRES DURING START?
YES
NO
CALCULATION OF THE SPEED, OF THE KILOMETRAGE AND OF THE TIME AT THE END OF THE FIRST INTEGRATION STEP OF 25 METRES
$V_f^2 = 2\gamma \times 25$
$PK\alpha = PK\pi + 25$
$\Delta t = \frac{2d}{V_f}$
TOTALIZE THE TIME IN THE TOTALIZER STORES
CALCULATION OF THE SPEED, OF THE KILOMETRAGE AND OF THE TIME AT THE END OF THE SECOND INTEGRATION STEP OF 25 METRES
$V_f^2 = V_i^2 + 2\gamma\, 25$
$PK\alpha = PK\pi + 25$
$\Delta t = \frac{2d}{V_i + V_f}$
TOTALIZE THE TIME IN THE TOTALIZER STORES
CALCULATION OF THE SPEED, OF THE KILOMETRAGE AND OF THE TIME AT THE END OF THE INTEGRATION STEP OF 50 METRES
$V_f^2 = V_i^2 + 2\gamma\, 50$
$PK\alpha = PK\pi + 50$
$\Delta t = \frac{2d}{V_i + V_f}$
TOTALIZE THE TIME IN THE TOTALIZER STORES
TEST
DOES THE SECTION CONCERNED CONTAIN A BRAKE APPLICATION POINT ?
NO
YES
TEST
IS THE ACTUAL KILOMETRAGE HIGHER THAN THE KILOMETRAGE OF THE BRAKE APPLICATION POINT ?
NO
YES
TEST
HAS THE MAXIMUM SPEED AUTHORIZED FOR THE SECTION BEEN REACHED OR EXCEEDED ?
$V_i = V_M$
NO
YES
CALCULATION OF THE SPEED, OF THE DISTANCE, OF THE KILOMETRAGE AND OF THE TIME AT THE POINT OF INTERSECTION OF MAXIMUM SPEED AND ACCELERATION
$V_f = V_M$
$d' = \frac{V_M^2 - V_i^2}{2\gamma}$
$PK\alpha = PK\pi + d' = KI$
$t = \frac{2d'}{V_i + V_M}$
TOTALIZE THE TIME IN THE TOTALIZER STORES
TEST
HAS THE END OF THE SECTION CONCERNED BEEN REACHED ?
NO
YES
B
C
5
9
8
7
D


PUNCHING OF THE RESULTS
TEST
DOES THE SECTION CONCERNED CONTAIN A BRAKE APPLICATION POINT ?
NO
YES
CALCULATION OF THE SPEED, OF THE KILOMETRAGE, AND OF THE TIME AT THE END OF THE SECTION CONCERNED
$v_f = v_M$
Δe = KILOMETRAGE AT END OF SECTION, LESS KILOME--TRAGE AT POINT OF INTERSECTION
$\Delta t = \frac{\Delta e}{v_M}$
TOTALIZE THE TIME IN THE TOTALIZER STORES
CALCULATION OF THE SPEED, OF THE KILOMETRAGE, AND OF THE TIME AT THE POINT OF BRAKE APPLICATION
$V_f = V_M$
Δe = KILOMETRAGE AT BRAKE APPLICATION POINT, LESS KILOMETRAGE AT POINT OF INTERSECTION
$PK\alpha$ = KILOMETRAGE AT BRAKE APPLICATION POINT
$\Delta t = \frac{\Delta e}{V_M}$
TOTALIZE THE TIME IN THE TOTALIZER STORES
PUNCHING OF "TIMETABLE" CARD
PUNCHING OF THE RESULTS
TEST
DOES THE SECTION END AT A STOPPING STATION ?
YES
NO
REGARD THE MAXIMUM SPEED ON THE FOLLOWING SECTION AS ZERO
READING OF THE FOLLOWING "BRAKE APPLICATION POINT" CARD
CALCULATION OF THE SPEED, OF THE KILOMETRAGE, AND OF THE TIME AT THE END OF THE SECTION CONCERNED
Δe = KILOMETRAGE AT THE END OF THE SECTION, LESS KILOMETRAGE AT THE BRAKE APPLICATION POINT
$PK\alpha$ = KILOMETRAGE AT THE END OF THE SECTION
$\Delta t = \frac{2\Delta e}{V_i + V_f}$
TOTALIZE THE TIME IN THE TOTALIZER STORES
B
C
5
9
8
7
D
10



10
7
B
C
D
PUNCHING OF "TIMETABLE" CARD
TEST
HAS THE FOLLO-
-WING CARD BEEN READ ?
NO
YES
TEST
IS THE KILOME-
-TRAGE REACHED HIGHER
THAN THE KILOMETRAGE AT
THE END OF THE
SECTION ?
NO
YES
CALCULATION OF THE DECELE-
RATION, DEPENDING ON THE
SECTION PROFILE
$a = a_0 \pm \frac{i\,g}{k}$
CALCULATION OF THE SPEED,
OF THE KILOMETRAGE AND OF
THE TIME AT THE END OF THE
SECTION CONCERNED
$V_f^2 = V_i^2 - 2\gamma\Delta e$
Δe = PKα – KILOMETRAGE AT THE
END OF THE SECTION
$\Delta_t = \frac{2\Delta e}{V_f + V_i}$
TOTALIZE THE TIME IN THE
TOTALIZER STORES
(NEGATIVE ACCUMULATION
CALCULATION OF THE SPEED
OVER THE DECELERATION
CURVE
$V_M^2 = V_{M\pi}^2 - 2ad$
TEST
IS THE SPEED
OVER THE DECELERATION
CURVE LOWER THAN THE
SPEED REACHED ?
$V_M - V_f$
NO
YES
TEST
IS THE KILOME-
-TRAGE REACHED LOWER
THAN, OR EQUAL TO, THE
KILOMETRAGE AT THE END
OF THE SECTION ?
LOWER
EQUAL
PUNCHING OF THE "TIMETABLE" CARD
B
C
11


B
C
11
TEST
IS THE SPEED REACHED HIGHER THAN, OR EQUAL TO, THE MAXIMUM SPEED ON THE SECTION?
NO
YES
CALCULATION OF THE BRAKE APPLICATION POINT IN RELATION TO THE SPEED REACHED
$e = \frac{V^2 - V_f^2}{2a}$
TEST
IS THE NEW BRAKING DISTANCE SUFFICIENT FOR THE DECELERATION ?
YES
NO
CALCULATION OF THE SPEED, OF THE KILOMETRAGE, AND OF THE TIME AT THE POINT OF INTERSECTION (ACCELE--RATION - DECELERATION)
$V_i^2 = \frac{V_i^2 a + V_d^2 \pi \gamma}{\gamma + a}$
$\Delta e = \frac{V^2 M\pi - V_i^2}{2(\gamma + a)}$
$PK\alpha = PK\pi + \Delta e$
$\Delta t = \frac{2\Delta e}{V_i + V\pi}$
TOTALIZE THE TIME IN THE TOTALIZER STORES
PUNCHING OF THE RESULTS
CALCULATION OF THE SPEED, OF THE KILOMETRAGE, AND OF THE TIME AT THE END OF THE SECTION CONCERNED
$V = V_f$
Δe = KILOMETRAGE AT THE END OF THE SECTION, LESS KILOMETRAGE REACHED
$PK\alpha$ = KILOMETRAGE AT THE END OF THE SECTION
$\Delta t = \frac{2\Delta e}{V_i + V_f}$
TOTALIZE THE TIME IN THE TOTALIZER STORES
PUNCHING OF "TIMETABLE" CARD

APPENDIX VI.

Direction of running	Line		Code		Weight of loco. (in tons)	Weight of rake (in tons)	Type of loco.	No. of the section	Station	Speed attained	Performance						Type of timetable					
											Running time			Stopping time			Running time			Stopping time		
	No.	Route	Traction	Rake							H	M	S	H	M	S	H	M	S	H	M	S
1	0940	00	2	1	108	0450	204	00	Brussels-South													
								11	Hal	56		11	22					12	30			
								24	Enghien . . .			12	16		23	38		13	30		26	00
								30	Bassilly . . .			7	54		7	54		8	30		8	30
								48	Ath . . .			11	03		11	03		12	30		12	30
								56	Leuze			10	33		10	33		11	30		11	30
								67	Tournai . . .			14	07		14	07		15	30		15	30

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

18th SESSION (MUNICH, 1962).

QUESTION 6.

Co-ordination between main line railways and metropolitan or suburban railways (including elevated, underground and other specialized railways). Transfer points (distances, positions, arrangements); lay-out of the lines; town-planning and economic considerations.

REPORT

(Austria, Belgium, Bulgaria, Cambodia, Congo, Czechoslovakia, Denmark, Ethiopia, France and French Community, Greece, Guinea, Hungary, Italy, Lebanon, Luxemburg, Morocco, Netherlands, Poland, Portugal and overseas territories, Rumania, Spain, Switzerland, Syria, Tunisia, Turkey, Viet-Nam and Yugoslavia),

by A. Fioc,

Ingénieur en Chef, Chef Adjoint des Etudes Générales à la Société Nationale des Chemins de fer Français.

SUMMARY

1. FOREWORD.

It appears from reading the Report — as is already clearly seen from the above summary — that the Reporter has extended the field of his enquiry to cover the whole of the problems involved in operating suburban railways and their connections with the metropolitan systems on the one hand and main line services on the other.

The serving of large cities raises in effect ever increasing and more pressing problems for the railway Administrations responsible for them. In full agreement with his colleague Dr.-Eng. RECKER and the General Secretariat of the I.R.C.A., the Reporter felt that this question required to be studied as a whole in order to ascertain, if possible, certain points of doctrine.

The resultant questionnaire was sent by the General Secretariat of the I.R.C.A. to 83 Governments, Organisations or Administrations in the countries covered by the author of this report. Of these, 16 Administrations sent in replies to the Reporter, who also received acknowledgements regretting they could not help from 3 Governments, 6 Organisations, and 32 Administrations who do not operate any suburban services.

The Reporter wishes to express his sincere thanks to the Administrations who replied to the questionnaire. He is particularly pleased to be able to stress the careful precision and exhaustive characteristics of most of these replies, which proves the interest aroused by the problems under discussion.

The 16 Administrations who replied to the Reporter were the following (the letters in brackets refer to the abbreviations under which they are officially known For the sake of brevity, these will be used in the text of the report) :

— Austrian Federal Railways (ÖBB);

— Belgian National Railways Company (SNCB);

— Belgian National Light Railways Company (SNCV);

— Danish State Railways (DSB);

— Spanish National Railways (RENFE);

— Paris Transport Board (RATP);

— French National Railways Company (SNCF);

— Hungarian State Railways (MAV);

— Italian State Railways (FS);

— Netherlands Railways (NS);

— Polish State Railways (PKP);

— Portuguese Railways Company (CP);

— Swiss Federal Railways (CFF);

— Tunisian Railways Company (SNCFT);

— Turkish State Railways Company (TCDD);

— Vietnam Railways.

These 16 Administrations cover only 14 countries, since 2 countries both sent in 2 replies: Belgium (SNCB and SNCV) and France (RATP and SNCF).

The Reporter does not intend to present all the replies received synoptically, but rather to give all the facts and policies reported as synthetic a way as possible. In the following report, he will, however, give many actual quotations from the replies received on many particularly interesting points :

2. CHARACTERISTICS OF THE SUBURBAN SERVICES OPERATED BY THE RAILWAY ADMINISTRATIONS WHO REPLIED TO THE I.R.C.A. ENQUIRY.

Structure and layout of the lines.

Except for the Viet-Nam and NS railways, all the Administrations who replied to the enquiry operate at least one suburban system in the meaning of the questionnaire.

The case of the NS is altogether special. The geographical and demographical characteristics of the western part of Holland

are such that the NS system in this region is the result of the juxtaposition of suburban services which interpenetrate very considerably (293 km) of closely linked lines connecting 10 important cities, 4 of them of great importance : *AMSTERDAM, ROTTERDAM, THE HAGUE* and *UTRECHT*). But, owing to the absence of any predominating city, certain essential aspects of suburban traffic, such as its disequilibrium at certain peak hours, are almost completely lacking. However, if the NS cannot isolate any classic suburban services, a great number of the problems covered by the enquiry also concern them and their reply has been an invaluable contribution to the study.

It should be noted that certain Administrations operate suburban services around several large cities, for example :

— RENFE (*MADRID, BARCELONA, BILBAO*, and to a lesser degree, *SAN SEBASTIAN*);

— FS (*ROME, MILAN, TURIN, NAPLES*) ;

— PKP (*WARSAW, GDANSK*);

— TCDD (*ANKARA, ISTANBUL, IZMIR*).

However, certain Administrations (SNCB, CFF, SNCF) report that from certain aspects the services which they operate around some large cities not included in this list, such as *ANTWERP, BASLE, LYONS*, meet most of the criteria for suburban services, but are not considered as completely significant as those organised respectively around *BRUSSELS, ZURICH* and *PARIS*.

The enquiry therefore deals mainly with the following suburban services :

Country	*Cities*	*Administrations*
AUSTRIA	*VIENNA*	ÖBB
BELGIUM	*BRUSSELS*	SNCB + SNCV
DENMARK	*COPENHAGEN*	DSB
SPAIN	*MADRID* *BARCELONA* *BILBAO* *SAN SEBASTIAN*	RENFE
FRANCE	*PARIS*	SNCF + RATP
HUNGARY	*BUDAPEST*	MAV
ITALY	*ROME* *MILAN* *TURIN* *NAPLES*	FS
POLAND	*WARSAW* *GDANSK*	PKP
PORTUGAL	*LISBON*	CP
SWITZERLAND	*ZURICH*	CFF
TUNISIA	*TUNIS*	SNCFT
TURKEY	*ANKARA* *ISTANBUL* *IZMIR*	TCDD

An examination of the diagrams of the suburban lines corresponding to these different cases does not reveal any significant particularities as regards their layout : the lines radiate around the cities served, varying in number according the local geographical conditions (coastal or inland, for example), and more especially according to the density of population and importance of the currents of traffic. It can be noted that as a general rule parallel lines (« en rocade ») used for passenger transport only appear in the complicated railway networks around the largest cities.

Greater differences will be noted in the connections between large urban stations : 3 diagrams (fig. 1, 2 and 3) illustrate the classification which the Reporter has decided to use. Layouts of the type shown in figure 1, are those of terminus stations which are not connected to each other, at least by lines used for suburban traffic (*MILAN, PARIS, LISBON,* for example). Figure 2 (*BRUSSELS*) is an example of the opposite case in which all the stations of the urban zone have good connections with each other by the actual lines carrying the suburban traffic. This case is exceptional. However, *ZURICH* and *ROME* are about of the same type. Finally figure 3 (*WARSAW*) shows a fairly common intermediate case : certain lines are isolated with a single urban terminus station; other lines link up several urban stations.

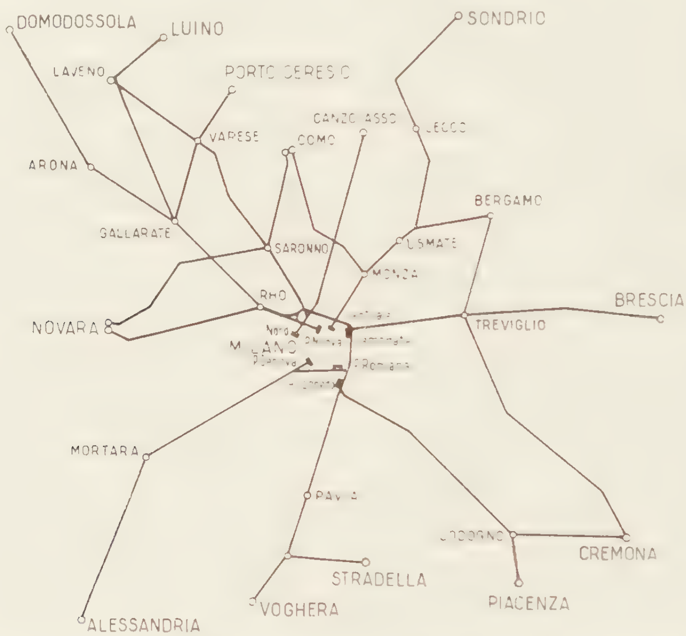


Fig. 1 — Diagrammatic map of the suburban lines around Milan.

Such situations are obviously an inheritance of the past on the one hand, and on the other, due to the remodelling which has taken place as imperious needs called for modifications to be made. The absence of a general plan at the beginning has led, especially in the large cities, to situations of the type shown in figure 1. Such situations are put up when natural conditions

or the high degree of urbanisation makes it very difficult and above all very costly to make any changes. Partial replanning has, however, in certain cases, led to the realisation of situations of the type shown in figure 3, whilst those of figure 2 are only possible in modern times at the cost of very expensive works, and so far, only in cities which whilst very important, have not the high level of population of the biggest capital cities.

Length of the lines.

The extent of suburban railway system is connected not only with the numbers of the populations to be served, but also, it appears, with the character of the central city: an industrial and commercial city, with the same population, will have a greater extent of suburban lines than a capital of a dominatingly political, administrative or cultural character. This seems to be so if we compare the lengths of the suburban systems of *BARCELONA* (430 km) and *MADRID* (184 km) on the one hand, and, perhaps less definitely so, *MILAN* (1 204 km) and *ROME* (811 km).

The rules governing the calculation of the length of the system would appear not always identical from one Administration to another, especially as regards taking into account common sections, and also the actual idea of the suburban zone which at times appears to have been interpreted very widely, so that it is not possible to be more precise in such comparisons.

However, the following table gives the length of the suburban lines of 5 cities, calculated on identical bases :

Cities		*Mileage*	
BRUSSELS	SNCB SNCV	258 km 182 km	440 km
COPENHAGEN	DSB		220 km
LISBON	CP		133 km
PARIS	SNCF RATP	952 km 35 km	987 km
TUNIS	SNCFT		17 km

Method of traction.

Apart from the SNCFT, all the Administrations have already electrified a large proportion of their suburban lines (at least 30 % except the TCDD and in fact the MAV, which are still below this figure). Certain Administrations have already completed the electrification of their suburban lines (RENFE, SNCV, RATP, NS), whilst many have already electrified more than 50 % or soon will have done so thanks to the work now in hand (SNCB, SNCF, FS, PKP, CP).

It should be made quite clear here that all the Administrations for whom this problem still arises, propose to extend the electrification of their suburban lines. Many of them have work in hand or definite programmes.

The historical and geographical dispersion of the systems used, which is well known in the case of the main lines, also occurs in the case of the suburban lines,

Fig. 2. — Diagrammatic map of the Brussels suburban lines (Belgian National Railways - SNCB).

Legend : ▬▬ Passenger lines of the SNCB.
9 No. of inhabitants (in thousands).

with in addition the special voltages sometimes used with D.C. for such services (750 V on the SNCF, 600 and 800 V on the PKP, 600 V on the SNCV).

Diesel traction at first occurs in the case of suburban services in the form of railcars, which are used either at slack periods on the important lines, or for all the services on feeder lines. The Reporter was also surprised to find that Diesel locomo-

tives are normally used for suburban services by several Administrations (SNCB, ÖBB, DSB, FS, SNCFT). The Diesel locomotive is in effect generally considered to have characteristics — of acceleration in particular — hardly suitable for the special requirements of suburban services.

heavy traffic is carried, the luminous automatic block (BAL) still is not the system most used in most cases. However, the SNCB, SNCFT, RENFE, and CP have equipped all or nearly all their suburban lines with this. On the SNCF, suburban lines equipped with BAL represent 60 %

Fig. 3. — Diagrammatic map of Warsaw suburban lines.
Echelle = Scale.

The replies of the Administrations on this point did not make it clear whether they considered this to be a final solution or merely the first stage in modernisation before electrification.

As for steam traction, although appreciably on the decline, this still represents a proportion of the mileage varying approximately from 20 to 50 % (ÖBB, SNCB, SNCF, FS, DSB, PKP).

Signalling.

In the field of signalling, although it is a question in principle of lines on which

of the total, as is shown in figure 4 which gives the diagram of the signalling equipment of the suburban lines of the Paris region.

In general, the high cost of modern signalling installations such as BAL has obviously led the Administrations strictly to limit the equipment of the lines to traffic requirements. Thus figure 4 shows quite clearly that certain lines of the Paris region are modestly equipped, either with the manual mechanical block, or even with simple telephone sections. The same scale of the equipments can be seen on nearly all

the Administrations, according to the amount of traffic on their suburban lines.

The lengths of the sections vary from a few hundred metres to 1 500 m in the case of BAL, and from 2 000 to 3 000 m in the case of various types of manual block. If

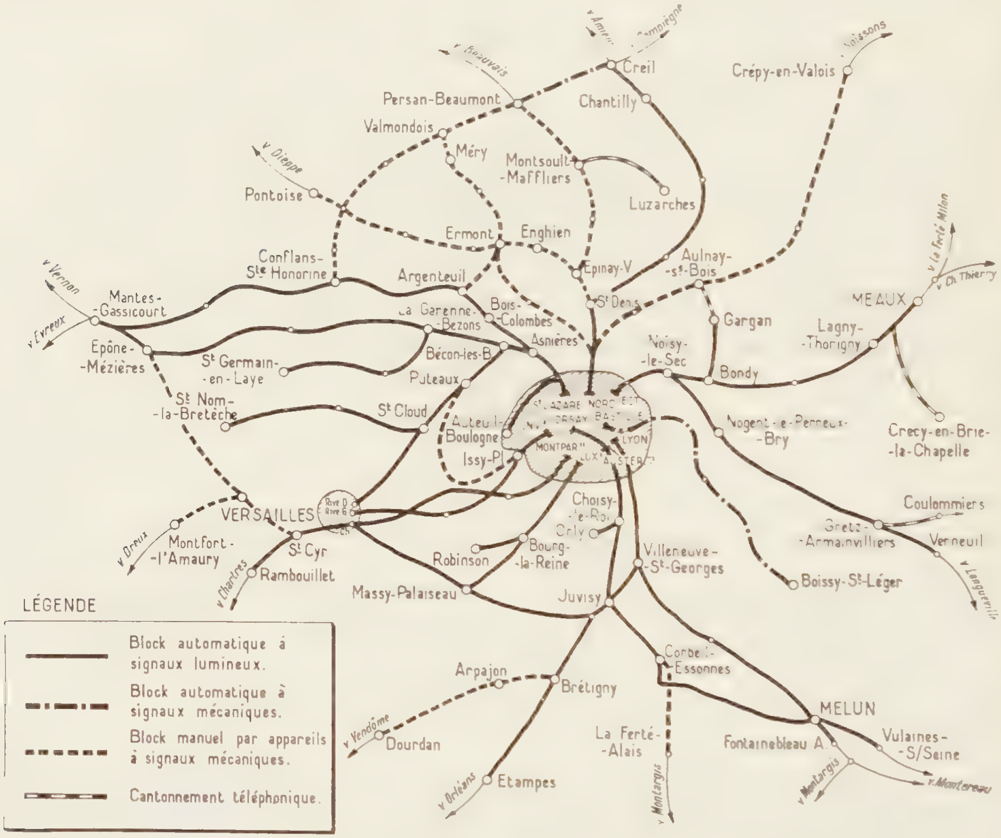


Fig. 4. — Diagram of the signalling installations on the suburban lines of the Paris Region.

Legend : ——— automatic block with light signals.
—.—. automatic block with mechanical signals.
- - - - - - Manual block with mechanical signals.
▬▬▬ Telephone sections.

there are merely telephone sections, the spacing of the stations which will be mentioned later decides the length of the sections.

Platforms.

Like the signalling, the height of the platforms is an important factor in the capacity of suburban lines. It is in fact indisputable that, everything else being equal, high platforms favour rapid passenger flow. However, it would appear that except on the DSB and to a lesser degree on the SNCF, the volume of traffic

is not the determining factor which has led the Administrations to choose between high and low platforms. In general, each Administration has a single type of platform, or a predominating type. It must however be noted that certain Administrations report the generalised use (SNCFT) or occasional use (SNCB, DSB) of intermediate platforms, 70 to 75 cm above rail level. The use of high platforms does in fact mean a certain risk of accidents at stations on a curve, as there is a dangerous gap between the platform and the floor of the coach. Intermediate platforms reduce such risks whilst considerably improving the output compared with low platforms.

No Administration has solved the difficult. problem of a design of carriage steps suitable for various types of platforms. However, mention must be made of the new suburban stock of the SNCF with lowered floors, the steps of which are suitable both for intermediate and low platforms.

Type of rolling stock used.

The stock used for suburban services obviously depends very closely upon the type of traction used.

On electrified lines, reversible rail motor coach sets are more or less in general use, consisting of one or several smaller sets (or elements), practically never separated, consisting of two to four bodies with motor units and trailers. The smaller sets nearly all have automatic couplings at each end, which makes it easy to adapt the number of sets making up the train to the expected traffic at different hours of the day. The number of passengers carried is 80 to 150 per coach, the higher number involving some 40 to 50 % standing places. Fig. 5 is a diagram showing one of these basic sets (Portuguese Railways Co.). It can be seen from this diagram that there are two entrance doors per coach. This is also the case of the SNCB sets. The SNCF sets have a greater number of doors : 4 on the D.C. stock delivered since 1954, 3 on the single phase stock delivered since 1960. Such arrangements shorten the time required at the stations.

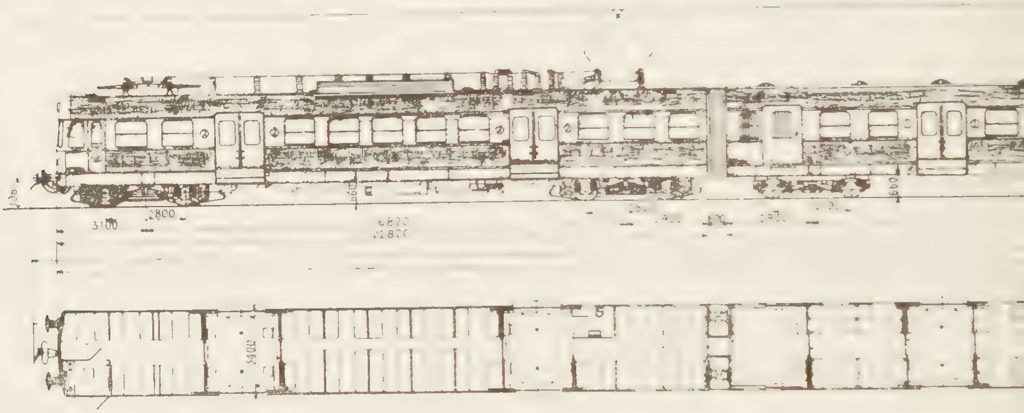
The use of such sets on the electrified sections is not however systematic; a certain number of Administrations, even with total electrification (CFF) have only a small number of reversible rail motor coach sets; they run their electrified suburban lines mainly with coaches of the classic type hauled by ordinary locomotives (FS, CFF, MAV). Although these Administrations give no justification for such a policy in the replies they sent to the Reporter, it is likely that they have made such a choice for the same reasons as the SNCF which also makes use simultaneously of both solutions on certain electrified suburban lines. A service by rail motor coach sets, well adapted from the technical point of view to the special problems of suburban traffic, thanks to its flexibility and high acceleration capacity, is in effect a costly solution. Such stock, strictly specialised, owing to the great variations in the traffic at different hours of the day and the complete closing down for several hours at night, can never be fully utilised. On the contrary, it is usually easy to get complete user, if not of the coaches at any rate of the electric locomotives, which can be used for other services than suburban services when these are reduced or suspended. With such solutions, the coaches are either ordinary bogie or axle coaches, or, more rarely on the lines of large cities, specially designed coaches for suburban traffic, in particular from the point of view of entering and leaving them (SNCB, SNCF). The number of places per coach is of the order of 80 to 150, 30 to 50 % being standing room.

The use of Diesel railcars, with or without trailers, for the services at slack hours or on branch lines, does not call for any special comment. This practice is reported by nearly all the Administrations, but is only used for a very small proportion of the traffic. It does not appear that this type of rolling stock has been specially designed for suburban services, nor have the Diesel locomotives which work the sub-

urban services with rakes of ordinary coaches.

In the case of steam traction, the Administrations use coaches that differ little from those used with electric traction. As a matter of interest, it may be mentioned that the ÖBB still run a few steam railcars hauling ordinary coaches.

thereto. In this connection, it would appear that operators will have to modify their ideas. It appears likely that in the future daily modifications in the capacity of trains made up of ordinary coaches will have to be given up. On the other hand, the example of the FS must be quoted, who record each day the user of all their sub-



Maker	type of electrification 50 cycles
Year of construction .	1954/57
Number of rail motor coaches	25
Brake	compressed air
Axle boxes	roller bearings
Heating	electric - resistance tubes
Lighting	electric
Alarm signal	provided

MOTORCOACH SERIE Myfc 2001 to 2025.

Tare	57 500 kg
Load	14 000 kg
Wheel arrangement	two 2-axled gogies
Number of motors	4
Wheel diameter	1 000 mm
Maximum speed	90 km h
Nominal continuous power of the 4 motors	1 000 kW
Power at the hourly rating (U.I.C.-610)	1 100 kW

Motors
A.C. com
Maximum
Makers
R.p.m.
Places :
seated
standing
total

Reference power (U.I.C.-614) : 1400 HP.

Fig. 5. — Diagram of the electric rail motor coach se

Composition and capacity of the trains.

It was reported above that the composition of the electric rail motor coach sets was regularly adapted to fluctuations in the traffic according to the hour of the day. Although this operation is carried out less flexibly in the case of rakes of ordinary coaches, the Administrations usually follow the same rules in this case. However, most of them appreciate the difficulties and resultant cost, and have drawn attention urban trains in order to adapt them to actual requirements.

On the whole, contrarily to what might be thought *a priori*, suburban trains have not very high individual capacities, even in the case of the most important metropolitan traffic. The capacity is nearly always well below that of the long main line trains. It is rare in fact for rail motor coach sets to consist of even 6 coaches, i.e. 800 to 900 passengers at the most; in the case of trains made up of ordinary coaches, these are never more than 8 coaches long.

or the equivalent, i.e. rather less than 1 000 passengers (seated + standing) [1]. It is remarkable in addition that the heaviest concentrations of traffic are not always worked by the longest trains in existence. Such an apparent contradiction is in reality easy to explain : on the lines with the heaviest traffic, frequent services are long trains; on the other hand, it makes it essential to have a very short standing time in the terminal stations, which is incompatible in any case with the possibility of having the correct number of passengers on the long trains.

* * *

type
V
ens, AEG
l Oerlikon

INTERMEDIATE TRAILERS
SERIES Ryle 2001 to 2025

No. of trailers	25
Tare	29 500 kg
Load	11 000 kg
Wheel diameter	840 mm
Places :	
seated	68
standing	72
total	140

DRIVING COMPARTMENT TRAILERS
SERIES RPyfc 2001 to 2025

No. of trailers	25
Tare	30 000 kg
Load	15 000 kg
Wheel diameter	840 mm
Places :	
seated	92
standing	68
total	160

guese Railways for the suburban services around Lisbon.

essential in any case as the public expects to be carried without having to wait. The very short intervals between trains on such services does not justify the use of very

[1] This refers to the composition at the present time, but, for example, the SNCF is considering increasing the capacity of the electric trains from the Gare St-Lazare to 4 twin bodied units, i.e. 1 200 places, and that of the trains of ordinary coaches from the Gare du Nord to 1 500 places (electric locomotive hauling the train).

Only the SNCF and the RATP explained the rules according to which the number of standing places are calculated. These rules are laid down in both cases by orders from the public authorities; these allow for each square metre of space available (platforms and corridors) :

— 6 standing passengers on the RATP;

— 5 second class and 4 first class passengers on the SNCF, the number of passengers standing being less than or equal to 40 % at most of the number of seats available.

The user is greater on the short runs and still more so on the urban services. This applies to the RENFE, TCDD, RATP and SNCV where on all or some of the trains there are more standing places than seats, but only on fairly short runs in principle.

Certain Administrations (CFF, DSB) state

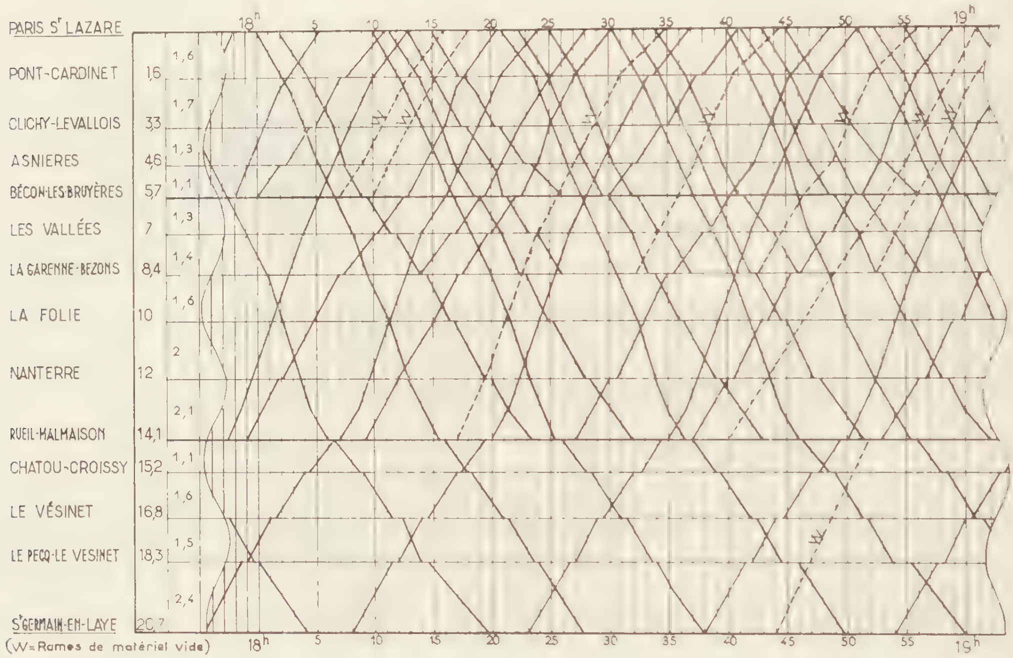


Fig. 6. — Extract from the train working diagram of the suburban trains between Paris - Saint-Lazare and Saint-Germain-en-Laye.

W = trains of empty coaches

that they do not have any standing room. The trains are made up in such a way that all passengers travel seated, except at the rush hours in the case of short runs to the terminal stations.

* * *

Hourly capacity.

The hourly capacity is in addition closely linked up with the maximum possible frequency of train departures. This maximum frequency depends directly or indirectly on a considerable number of factors. One of these is the flexibility with which the sets can be reused at the stations at the end of the run : from this point of view, reversibility of the rakes, i.e. the provision of a driving compartment at the other end of the set is certainly the decisive factor.

Reversibility is the rule in the case of all the electric rail motor coach sets; it would appear to be the exception in the case of trains made up of ordinary passenger coaches, no matter what method of traction is used. Only the SNCF has completely generalised reversibility, even in the case of steam traction. It has found this of the greatest benefit in carrying out the service and considers that the small amount of capital involved was very well spent.

* * *

The operating method which allows of the greatest number of passengers being carried from the terminal stations is without doubt, all other things being equal, that of the parallel spaced services. This system is effectively used by some administrations, either permanently on part or on all their lines, or at certain hours of the day, especially at the slack hours (TCDD, CP, ÖBB, SNCF, etc.). In fact the maximum traffic that can be worked in this way would appear to be of the order of 6 to 12 trains an hour, i.e. about 5 000 to 10 000 passengers per hour per line.

Parallel services imply, moreover, special lines and exclusively stopping services, which is only admissible over short distances, otherwise the journey time becomes prohibitive. Suburban lines of 30 to 40 km length are commonly found in nearly every country; longer lines have been reported around the large cities. On the other hand, the same lines nearly always have to carry the suburban, main line and goods traffic. The Administrations have to fit this multiple use in with the necessary differentiation in the speeds of the suburban trains. It is up to the timetable experts to make the best of all these requirements, taking into account in addition the particular physionomy of the suburban traffic. Figure 7 is an extract from the train running graphs for the suburban trains between *ZURICH HB* and *RAPPERSWIL*, drawn up under such conditions. In the concrete examples given by the Administrations, there are peaks of 4 to 10 suburban trains per hour per line with this method of working, i.e. about 4 000 to 10 000 passengers.

When the amount of traffic makes it necessary to set aside one or more groups

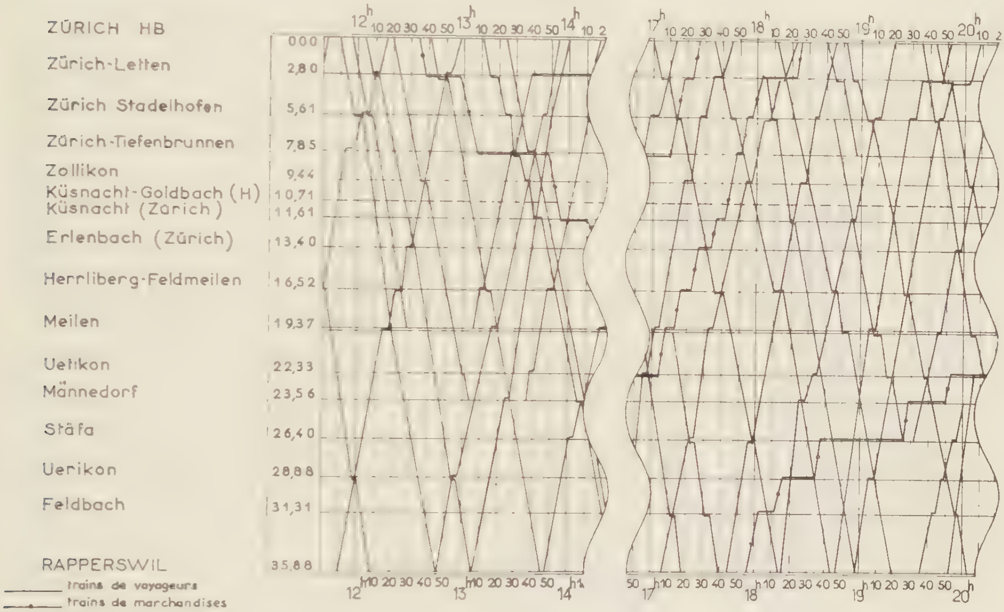


Fig. 7. — Extract from the train working diagram of suburban trains between Zürich HB and Rapperswil.

—— passenger trains.
—.—.—. goods trains.

of lines for the suburban services and it is also necessary to differentiate the speeds, the classic solution is that of working « by zones ». The line is divided up into zones (usually 3 or 4); each rake is allocated to a zone, i.e. it runs as a through train from the terminus station to the station at which its zone begins and then as a stopping train serving all the stations in its zone (or vice versa in the case of traffic to the centre). Departures from the terminal station (or return runs to the latter) take place obviously in such an order that the more direct trains are not held up by the slower ones. This operating technique can only be applied in a limited number of cases : the SNCF uses it on its lines from Saint-Lazare and Montparnasse, the RATP on the Sceaux line; RENFE is considering using it for some of its most important services. Figure 6 shows an extract from the traffic diagram for suburban trains on the Saint-Germain-en-Laye line, which is run on this principle. At the present time, the following performances can be obtained with this type of operating : on the RATP 18 000 passengers at peak hours are carried by 18 trains on the Sceaux line, and as from the 1st October 1961 it will be possible to carry 50 % more owing to a corresponding increase in the composition of the trains; on the SNCF, 20 000 passengers at peak hours by 20 trains on a single line leaving Saint-Lazare (1).

In order to generalise such results, which appeared deserving of attention, the SNCF drew up in 1960, according to the timetables and train composition at that time, the hourly transport capacity at peak hours on its lines in the Paris region. The diagram summing up this investigation is appended (fig. 8). It shows the number of places per route during a peak hour in the most heavily loaded direction (from Paris). Actual capacity is slightly lower than the figures indicated in this diagram, as for many reasons, it is not possible to get 100 % user of the trains even at rush hours.

(1) This number of trains is considered the maximum possible with the present installations. However, the SNCF considers that it could be increased to 22 if certain unimportant modifications were made, which will be put in hand as soon as this is felt to be necessary.

Speed of suburban services. Periods during which the trains run.

The average speed depends amongst other things on the distances between stations or stopping points. These are remarkably constant from one railway to another. The following significant figures may be quoted : maximum distance : from 6 to 8 km; minimum distance from 0.6 to 1 km; average distance from 2.5 to 3.5 km. The two latter figures confirm the need to run through or semi-through trains as soon as the lines are more than 12 to 15 km long and the value of motor units with great acceleration and deceleration capacity.

In view of the wide range of maximum speeds, though mainly lying between 80 and 100 km/h, the average speeds differ quite a lot according to the way the run is divided up. On short runs from the terminal station, they are low (of the order of 30 km/h), even with modern methods of traction. For longer runs, the average speeds improve considerably and fairly regularly, up to 45 to 60 km/h in the case of runs of 30 km and over, according to the method of traction used.

It has already been reported that the suburban services are systematically closed down during the night. The replies received from the Administrations allow of a certain precision on this point : they close down for 4 or 5 hours, either from midnight to 4 a.m. (or 5 a.m.) or from 1 a.m. to 5 a.m. (or 6 a.m.). The traditional way of living explains some still later times of closing down and restarting (Lisbon, after 2 a.m.; Madrid, starting again about 6.30 a.m.).

This closing down time can be fully made use of for running goods trains which often run on the same lines as the suburban traffic — except in particular cases

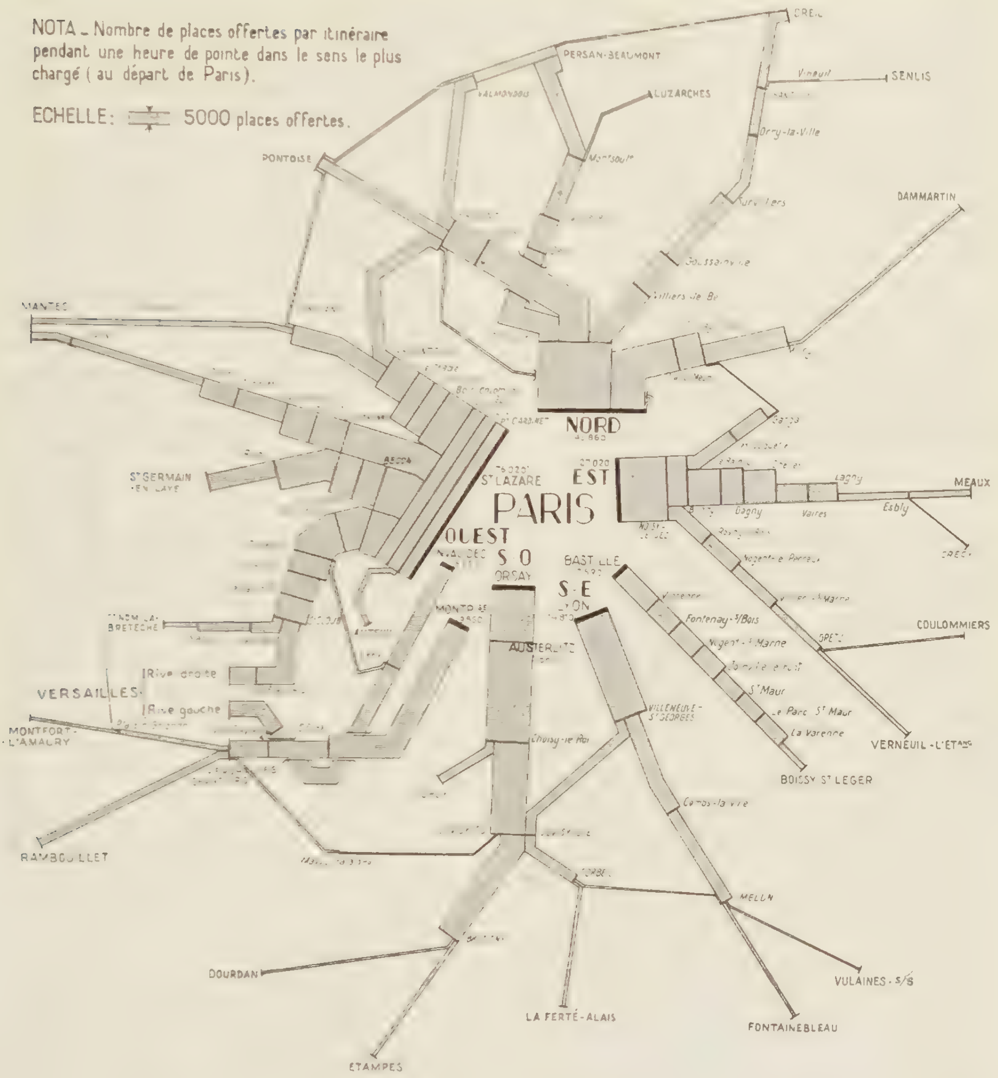


Fig. 8. — Suburban lines of Paris. Diagram showing peak hour traffic capacity in 1960.
NOTA. — Number of places available on each route during one hour of the peak hour period in the direction with the greatest amount of traffic (leaving Paris).
Echelle = scale : 5 000 places available.

such as the SNCV. The NS report that the greater part of their goods traffic is carried during this period when the suburban service is closed down, which it must be admitted in their case means practically all their passenger traffic. As the distances are short, it seems a very judicious solution. In any case, it makes it possible for

the NS to offer their passengers their well known and much appreciated spaced timetables on all their lines. But this solution remains the only one of its kind within the framework of this enquiry: all the other Administrations also make use of suitable periods during the day for running the goods traffic and main line traffic using the same lines as their suburban traffic.

Commercial organisation.

It appeared advisable to deal here with certain questions of a commercial order, though tariff problems will be dealt with in a special chapter later on.

Ticket collection.

The Administrations who have done away with platform barriers have not taken any special steps in connection with the suburban traffic, so that this category of passengers also have to have their tickets collected on the trains (CFF, FS, ÖBB, MAV). This control is unavoidably incomplete in the case of passengers travelling only a short distance near the head of the line. The Administrations concerned admit that this is so, but do not propose to modify their methods, except for reducing still further the regular checks en route by single inspectors in order to form large gangs making surprise checks (CFF).

The other administrations are able to check the tickets systematically on entering or leaving the platforms, with checks at times on the trains. In certain cases, to make the movement of passengers more fluid, there is only one platform check, usually on leaving (SNCF, TCDD). But whether there is complete control or the reduced control of the latter kind, the Administrations consider that there is a certain inevitable proportion of fraud, due to crashing the gates, lack of discipline on the part of passengers, etc.

In conclusion, every system allows of a certain margin of fraud. The reporter considers that the cost of control could undoubtedly be reduced without a corresponding increase in fraud if the fines on such cases were made considerably higher. A tendency to increase such fines has been recorded recently in France.

Parking near the stations.

Generally, there is no parking place reserved for passengers near suburban stations.

However, certain Administrations have made arrangements for parking and allow passengers to park their cars on payment of a parking fee at certain suburban stations (SNCB, SNCF, CFF). The charges are usually about 1 gold franc per 24 hours, with no limits on the period. There are also monthly parking rates, with a saving of about 50 %. But although the Administrations are doing all they can to develop this service, not much has been done to date, and future prospects are limited, as sites which can be used for this purpose are rare and costly.

In another order of ideas, certain railways have agreements of various kinds with the towns for the latter to make parking places near the stations on town property, part of the cost being borne by the railway (DSB, NS). In this case, there is no charge for parking, and vehicles can remain indefinitely, but railway passengers have no priority over other motorists. All the same, this is indubitably a facility for railway clients.

It is an indisputable fact that the development of residential areas at ever increasing distances from the railway implies a need for parking space at stations. But the railways cannot afford to provide such facilities at their own expense, and the towns are often unco-operative, as they point out with reason that the people using such car parks are usually those living in other districts. Only some solution to which all the communities concerned contribute through some regional organisation — such as the district of Paris — appears likely to be able to solve this important problem.

3. AMOUNT AND DISTRIBUTION OF SUBURBAN TRAFFIC.

Overall amount of traffic.

The statistics relating to the volume of suburban traffic which the Reporter received from the Administrations are summed up in the following table :

In making out this table, the cities were classified by decreasing number of suburban passengers for the last known year; it is moreover incomplete, quite apart from the blank spaces left, as the Administrations were not able to supply any statistics for certain cities, some of them very important ones (*BRUSSELS* [*SNCB*], *ISTANBUL*, *WARSAW*, *BUDAPEST*).

PARIS stands out clearly from the other cities which could be classified. It will be noted, moreover, that the average passenger journey on the suburban lines is about the same (12 to 18 km) around the different cities, except in the case of the Italian cities for which the replies received cover a more extensive suburban zone than those in other countries.

The detailed analysis of the statistical data supplied by the Administrations brings out, on the one hand, the following general evolution (in the number of passengers) : the suburban traffic was very high in the years 1928/1930 : there was great economic activity at that time, the railway was practically the only collective means of transport and private transport was still undeveloped. All these factors changed in the ten years before the second world war, and just before it the traffic had fallen off very appreciably. The general shortage of means of transport during and after the war restored considerable masses of suburban passengers to the railway (maximum recorded about 1946-1947), which have fallen off again, at least to some extent, as other public or private transport faci-

Cities		*Passengers and Passengers-km in million*			
		1930	*1938*	*1950*	*Most recent year for which figures were given (usually 1959 or 1960)*
PARIS (SNCF) . . .	P	356	250	301	316
	PK	5 000	3 780	4 190	4 490
COPENHAGEN . . .	P		32.8	62.7	78.3
	PK	—	402.5	801.8	952.9
GDANSK	P	—			59.7
	PK	—		-	895
PARIS (RATP Sceaux line only)	P		18	37	45.1
	PK	—	191.2	315.8	384.7
BRUSSELS (SNCV) .	P	—	44.4	54.5	44.8
	PK	—	—	—	—

Cities		*Passengers and Passengers-km in million*			
		1930	*1938*	*1950*	*Most recent year for which figures were given (usually 1959 or 1960)*
MILAN	P	—	—	—	43
	PK	—	—	—	1 530
ZURICH	P	—	24.3	—	32.8 (1)
	PK	—	340	—	554 (1)
VIENNA	P	—	—	—	32.1
	PK	—	—	—	—
LISBON (Sintra line only)	P	—	—	—	23.4
	PK	—	—	—	307
BARCELONA	P	—	—	23.0	21.4
	PK	—	—	—	—
NAPLES	P	—	—	—	19
	PK	—	—	—	816
BILBAO	P	—	—	7.6	18.9
	PK	—	—	—	—
ROME	P	—	—	—	13.0
	PK	—	—	—	750
TURIN	P	—	—	—	10
	PK	—	—	—	400
MADRID	P		—	5.1	4.7
	PK	—	—	—	—

(1) Figures refer to 1955.

Nota : This table does not include all the figures given by the Administrations, owing to the number of different years for which statistics were available, especially as regards some few years ago.

lities have become available. A new traffic trough therefore appeared about 1953-1954, followed in general by a slight upwards tendency since this date, owing to the strong tendency to expansion of the large cities.

Fluctuations in traffic.

Apart from these long term fluctuations, suburban traffic is subject to seasonal, weekly and daily fluctuations.

Most of the Administrations were able to give a table of indices for a recent year characterising the average daily traffic for each of the 12 months compared with the average daily traffic over the year. An examination of these tables shows that they can be divided into two distinct categories:

— the first, and most numerous, of which that of the *FS (MILAN)* and SNCF are typical, for example:

Month	*FS*	*SNCF*
January .	1.20	1.04
February .	1.15	1.03
March	1.10	1.05
April .	1.00	1.05
May .	0.95	1.04
June . .	0.85	1.03
July .	0.75	0.91
August	0.70	0.71
September .	1.00	0.95
October . .	1.05	1.05
November .	1.10	1.06
December .	1.15	1.08

These show a marked falling off in the summer and a high level of traffic in the winter; they reflect very clearly the way of life of the population of these countries: summer holidays, giving up using individual transport during the bad weather.

— Another category, represented only by *TCDD, PKP (GDANSK)* and *RENFE,* surprisingly show the peak and decline in the opposite months to the previous type. Here for example are the indices noted by the *TCDD* and *PKP (GDANSK)*:

Month	*TCDD*	*PKP*
January . . .	0.8	0.93
February. . .	0.8	0.89
March . .	0.9	0.91
April	1.03	0.93
May.	1.05	0.98
June.	1.1	1.11
July	1.2	1.20
August . . .	1.2	1.18
September . .	1.04	1.09
October . . .	0.9	0.96
November . .	1.02	0.89
December . .	1.0	0.96

As the Administrations in question made no comments upon these results, the Reporter is not able to give any certain explanation for this type of seasonal fluctuation.

Weekly fluctuations were not investigated. It appears of interest, however, to report the results obtained by the SNCF during traffic counts carried out in May 1960 (see Table on the following page).

Though referring to the traffic in the Paris region, no doubt these indices are more or less valid for most of the large cities; they show the need for rearranging the services on Sundays and to a lesser degree on Saturdays [1].

(1) However, the 5 day working week is the general rule in a certain number of cities covered by the enquiry (whereas in Paris it still seems to be 5 1/2 days). It is true that in such cities, the Saturday traffic is not much greater than that of Sunday.

Days	*Daily traffic index*	
	Compared with «normal» days, Tuesday, Wednesday, Friday	*Compared with the average for the week*
Monday .	0.95	1.07
Tuesday .	1	1.12
Wednesday	1	1.12
Thursday	1.02	1.14
Friday .	1	1.12
Saturday	0.75	0.82
Sunday .	0.55	0.62

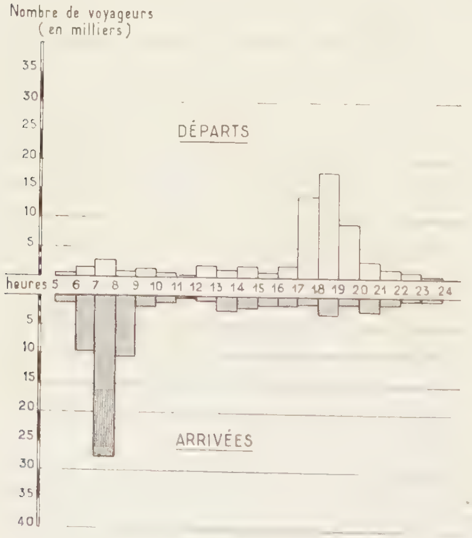


Fig. 9. — Graph showing the hourly distribution of the suburban traffic of Milan. (Traffic of November 1960.)

Nombre de voyageurs... = No. of passengers (in thousands). — Départs = leaving. — Arrivées = arriving.

The daily fluctuations in the traffic are much more marked. These are the ones which most closely characterise suburban traffic, since, as has already been said, this is due fundamentally to the alternating massive movement of the population due essentially to their hours of work.

Numerous graphs showing these fluctuations were sent in by the Administrations; it appeared of interest to retain three of these to illustrate this Report.

These are those for *MILAN*, *BARCELONA* and *PARIS-SAINT-LAZARE* (fig. 9, 10 and 11).

MILAN shows the relatively greatest peak of all the examples received : 70 % of the traffic is worked in 3 hours (the peak departure hours obviously varying from the peak arrival hours).

BARCELONA, on the other hand, shows the most regular traffic of those investigated; all the same 30 % of the traffic leaving or arriving is carried in 3 hours.

PARIS-SAINT-LAZARE, finally, represents an average case as far as peak traffic is concerned; about 56 % in 3 hours, which is the usual amount. But this is far from the absolute maximum hourly rate with 50 800 passengers travelling in a single direction [1].

An examination of these graphs throws light without further commentary on the need for and extent of the technical measures studied in chapter 2, such as the adaptation of the number and eventually the composition of the trains to requirements, a particularly careful study of the timetables, etc.

In the terminal stations, suburban traffic is usually worked from platforms which without being exclusively set aside for this purpose, nevertheless take such traffic by priority. Two characteristic diagrams are given here to illustrate this point, that for

[1] New counts, made in November and December 1960, showed that this number had increased to 57 900 passengers leaving at the peak of the rush hour.

PARIS-SAINT-LAZARE (fig. 12) and that for *ZURICH HB* (fig. 13).

At *PARIS-SAINT-LAZARE* the special platforms and lines grouped at one end of the station are used to a relatively large extent for the suburban traffic. A very large end platform, doubled again by a huge circulating area, with many access points, ensures that the circulation of passengers is a fluid as possible.

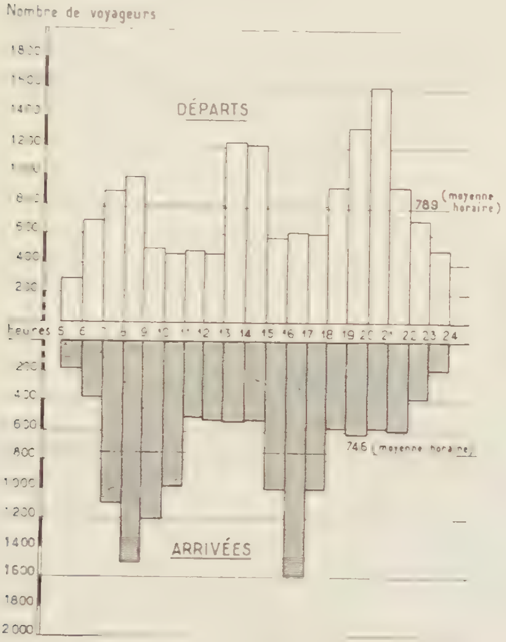


Fig. 10. — Graph showing the hourly distribution of the suburban traffic of Barcelona-Termino. (Traffic as in March 1960.)

Nombre de voyageurs... = No. of passengers (in thousands). — Départs = leaving. — Arrivées = arriving. — Moyenne horaire = hourly average.

At *ZURICH HB*, 3 lines and an ordinary platform, plus a secondary platform are allocated by priority to the suburban traffic and make it possible to deal with most of this.

The length of the platforms specially allocated to suburban traffic is 180 to 300 m, the usual figure being 200 m. (It can be seen from this that the composition of the suburban trains is not too generous.) As for the width, this varies from 5 to 10 m and exceptionnally 12 m.

Finally there is another characteristic of the suburban traffic and this is the pro-

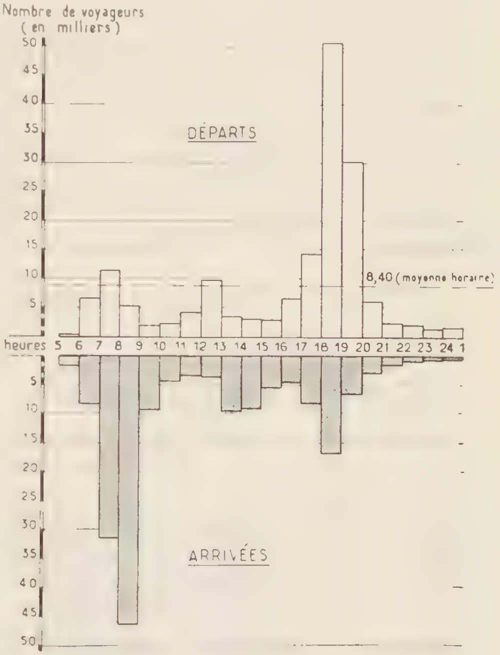


Fig. 11. — Graph showing hourly distribution of the suburban traffic from Paris-St-Lazare. (Traffic as in May 1960 on the busiest day of the week.)

gressive reduction, as the distance from the centre is the greater, in the number of passengers carried on the different sections of the lines in question. To bring out clearly the general character of this phenomenon, four different diagrams showing the distribution of the traffic along the suburban lines of *BRUSSELS, BARCELONA, COPENHAGEN* and *PARIS* are given (fig. 14, 15, 16 and 17). The progression of these diagrams is identical, whether they represent the traffic in both directions (fig. 14, 16 and 17) or in one direction only (fig. 15).

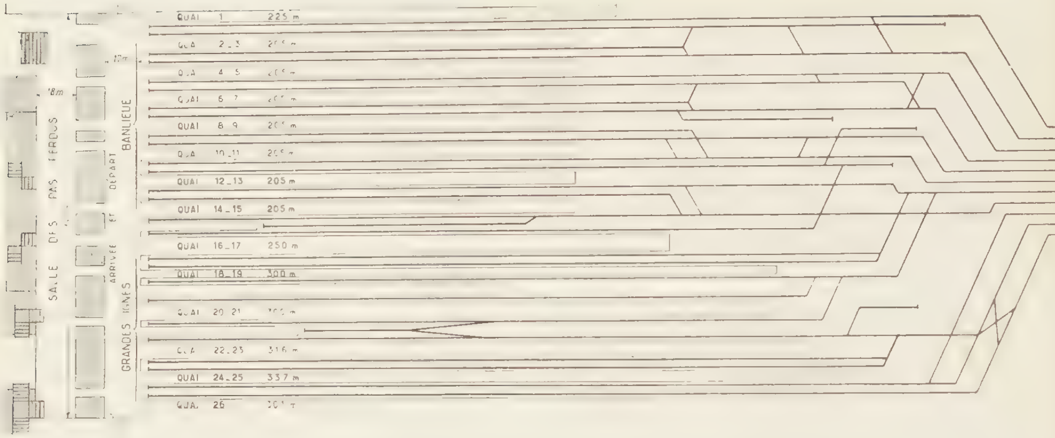


Fig. 12. — Diagram of the lines and platforms at Paris - Gare St-Lazare.

Voies et Quais { Trafic mixte assurant la presque totalité du trafic suburbain

Voies et Quais { Trafic mixte assurant la presque totalité du trafic "grandes lignes"

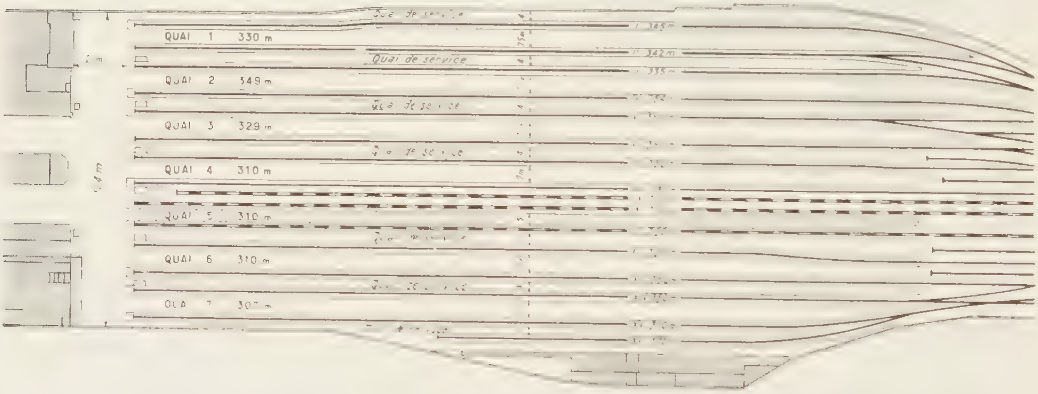


Fig. 13. — Diagram of the lines and platforms in Zurich HB station.

Lines and platforms { Mixed traffic carrying most of the suburban traffic.

Lines and platforms { Mixed traffic carrying most of the main line traffic.

It results from this point that those responsible for the operating must take care to adapt the number of places available to this rapidly varying demand. *A priori,* two methods would seem possible : the introduction of rakes for more or less far off destinations and multiplying the rakes for one of the nearer terminus stations, and modifying the composition of the rakes during the run. Although this question was not directly covered by the enquiry, an examination of the timetables

submitted by the Administrations shows that the first solution is very generally used, no matter what type of operating is in force. The second would appear to be exceptional, and this is not surprising in view of what it would entail as regards shunting engines in the intermediate stations and delays to the timetable which it would be hard to justify, at least in the case of trains running towards the centre.

* * *

I. FUTURE PERSPECTIVES FOR THE EVOLUTION OF THE SUBURBAN TRAFFIC.

The statistics sent in by the Administrations as well as the commentaries supplied with them show, in a very general way, that the present tendency is towards an increase in the suburban traffic.

However, the development expected is only moderate in most cases. Figures of

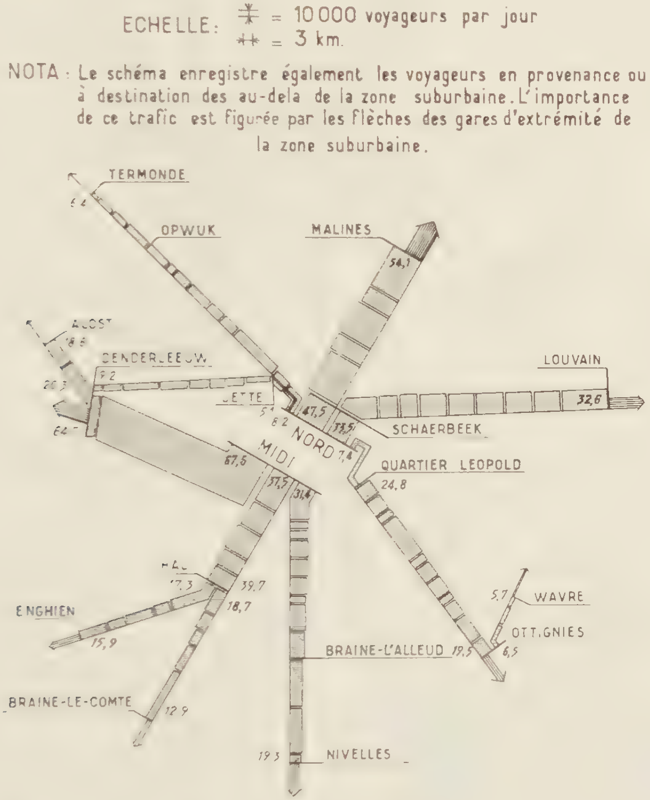


Fig. 14. — Diagram showing the distribution of the traffic (in both directions) along the suburban lines of Brussels (SNCB).

Echelle... = scale ÷ = 10 000 passengers a day
·|· = 3 km

NOTA. — The diagram also shows passengers coming from destinations beyond the suburban zone. The amount of such traffic is shown by the arrows at the end stations of the suburban zone.

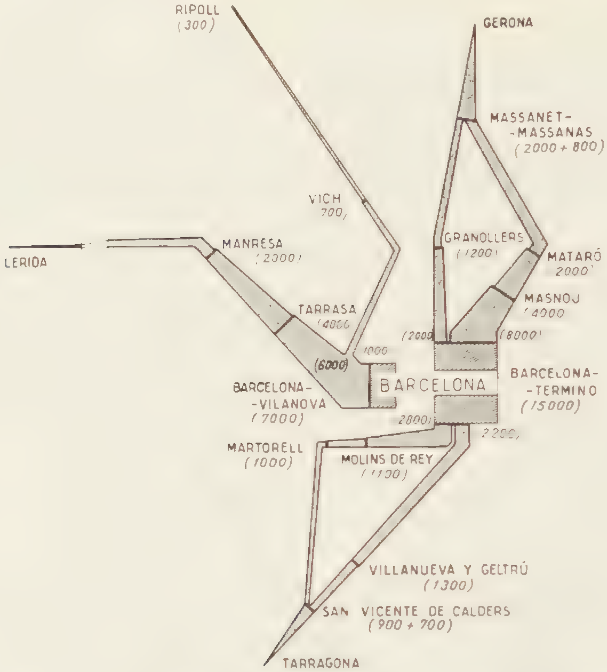


Fig. 15. — Diagram showing the distribution of traffic (one direction only - outwards) along the suburban lines of Barcelona (Traffic as in March 1960).

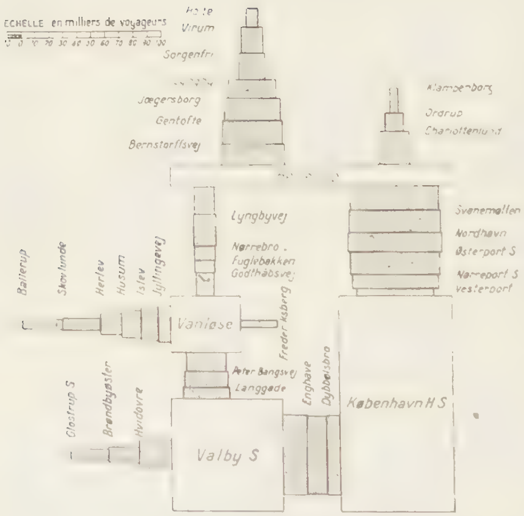


Fig. 16. — Diagram showing the distribution of the traffic (both directions together) along the suburban lines of Copenhagen, electrified lines only, according to a count taken on the 13th September 1956.

between 15 and 25 % have been quoted for the next 10 year period by the following Administrations: SNCB, DSB, RENFE, FS, CFF.

For the same period, the SNCF and RATP expect the increase to be more considerable: of the order of 50 % on the average in the case of the SNCF (with as much as 200 % on certain lines), and 30 to 60 % for the RATP (Sceaux line) according to the region served, as also the TCDD (70 %) and CP, the latter on their electrified lines at any rate (10 % per annum, and possibly more).

The PKP and SNCV on the contrary report a tendency to remain stationary, or even to decline. In the case of the PKP, this is due to the creation of suburban omnibus lines; in the case of the SNCV, to the increase in the number of private cars.

Amongst the Administrations which expect an increase in the demands for sub-

Fig. 17. — Diagram showing the distribution of traffic (both directions together) along the suburban lines of the Paris region (Traffic as in 1960).

En milliers de... = in thousands of paying passengers daily.

Echelle... = scale ////// 15 000 paying passengers daily.

urban transport, the opinion is generally held that the peak traffic will develop in proportion to this increase. In effect the expected increase in traffic relates to employees and workmen whose definite working hours are the cause of the peaks. In addition, the tendency towards the extension if not the generalisation of the 5 day week is bound to increase the peak traffic still more, as 5 days work leaves little latitude in spreading out working hours in the different kinds of work.

The Administrations are very conscious of the increased difficulties to be expected in this connection, if something is not done to prevent it. The FS, SNCF, RATP, TCDD and PKP all report having asked the Public Authorities to intervene in order to spread out the beginning and ending of working hours in the large cities.

Only the PKP have obtained any results so far, which they consider to be satisfactory. The requests of the other Administrations have in general been favourably received by the Public Authorities, who unfortunately have little power to promote such changes in working hours which would involve profound changes in the pattern of life of the populations and are therefore considered undesirable in spite of the advantages they would bring.

Long term action will be needed to obtain any appreciable results.

It should be noted that the TCDD considers that the only steps taken by the Public Authorities, especially as regards assistance in building at carefully selected sites, will be sufficient to reduce the size of the peak traffic in spite of the increase in the traffic they expect.

* * *

5. MEASURES UNDER CONSIDERATION TO MEET ANY POSSIBLE INCREASE IN SUBURBAN TRAFFIC.

In view of the problems and the burden imposed by the suburban services, problems which will tend to become aggravated as a result of the expected increase in this traffic, is it to the interest of the Administrations that such a development should take place, or would it not be better for them if steps were taken to ensure that part of the traffic was carried by some other method of transport ?

This is a delicate question, but the Reporter considered that it was worth going into.

A certain number of Administrations have at once to be removed from the discussions; in the case of the SNCF and RATP, the suburban traffic is, at least to some extent, the main object of their working. In other cases the question, whilst it could be considered from the point of view of the principles involved, is of no practical interest, because the Administrations in question have an obligation, in fact or legally, to carry all or nearly all the suburban and urban traffic (TCDD, DSB).

Apart from these exceptions, the position taken up by the Administrations on this point would appear to be founded on a consideration of two points of view : that of their direct interest in the development of this kind of traffic and that of opportunity.

On the first point, they are far from being unanimous : certain Administrations have expressed very explicitely the opinion that they have a direct interest in the development of the suburban traffic. This is the case, with no reservations, with the PKP, TCDD and CP, whilst the RENFE and ÖBB consider their interest therein is limited and corresponds with the present capacity of their installations and rolling stock.

A few other Administrations have given implicitely an equally affirmative reply (MAV, NS), whilst three others (FS, SNCB, CFF) have expressed a completely opposite point of view, justified by considerations concerning the special cost of such traffic and the inadequacy of the corresponding receipts.

The position of the SNCF is rather more delicate; its direct interest in the suburban

traffic is limited, and in particular the present position is not very satisfactory, but it considers that this does not prejudice any interest it might have in the development of the traffic above its present level. In other words, it does not exclude the possibility that the additional costs might be compensated by new receipts on condition that it has not to bear any further capital costs. In sum, starting from a slightly different point of view, the opinion of the SNCF practically coincides with that of RENFE and the ÖBB.

From the point of view of expediency, the Administrations are unanimous in considering that the suburban services are a Public Service which they cannot refuse to undertake. None of them has considered diverting all or part of the present or future traffic to other methods of transport, with the exception of traffic in the urban zones where other public transport services (tramways, metros, buses) can without inconvenience take the place of the railway.

Certain transfers affecting the suburban traffic, which will be dealt with later, have however taken place or been considered, but these come within the general framework of a reorganisation programme for the suburban services and do not imply, as far as the users are concerned, any repudiation of the idea of public service.

The reporter considers that the Administrations have an interest, without doubt, in voluntarily giving up the urban traffic to the greatest possible extent and also in diverting to the public urban transport services (which if necessary should be modified or extended) traffics to or from the first stations of the suburban zone, which are still within the city properly speaking. In effect on suburban lines with very heavy traffic, the services to the first few stations raise difficult technical problems, no matter what method of operating is adopted — even when the working is divided up into zones. It compromises the quality of the services to further off stations and can even be completely incompatible with the requirements of such services.

When increases are expected in the traffic, it would therefore be judicious to carry out technical and economic investigations in connection with such transfers of traffic, which would have the advantage of reserving the full capacity of the railway to meet those needs which it alone can satisfy.

Examples given by the Administrations of transfers of the operating (and not only of clients) [1] already made or under consideration are few in number:

— in Portugal, in 1918 a 26 km long line (*LISBON-CASCAIS*) was transferred to the « Sociedade Estoril ». Electrified with 1 500 V D.C. the line carried in 1959 a traffic of 21.2 million passengers (271 million passenger-km);

— in Belgium, the SNCB handed over to a private company in 1930 a 13 km long line (*BRUSSELS-TERVUEREN*) with little traffic, which today is worked by an omnibus service;

— in France, in 1938 the SNCF handed over to RATP the operating of the so-called Sceaux line (19.5 km) and part of the operating (driving and train staff) over the extension of this line to *SAINT-REMY-LES-CHEVREUSE* (16 km).

At the present time, the following matters are under consideration in France:

— completely handing over the operating of this latter line to RATP;

— the incorporation of two lines or sections of line of the SNCF: the Vincennes line and the section La Folie-Saint-Germain on the East-West cross line in a projected suburban system, the Regional Express Railway, which will be in close connection with certain SNCF stations outside Paris and with certain Metropolitan stations

---

[1] The transfer of clients which has been arranged would appear to be limited to the following cases:

CFF - transfer of urban traffic to the local tramways system;

PKP - partial transfer of the suburban traffic to State operated motor services.

within Paris, and have its own self-contained management (see chapter 8).

In order to be able to deal with the increase in suburban traffic, the Administrations are proposing to make use of the following technical means, which are mentioned in order of priority :

— electrification;

— improvement of the signalling;

— more frequent services;

— increasing the capacity of the trains;

— modifications to the stations with the heaviest traffic;

— doubling or quadrupling the lines;

— modifying the installations;

— exceptionally : taking the lines underground with stations at two levels; creating new stations in areas of rapid development.

This programme of measures can be considered satisfactory from the economic point of view, since the new capital works come at the end of the list, whereas the first measures mentioned assist in improving the productivity at the same time as they make it possible to increase the output.

* * *

6. FIXING THE FARES.

The replies received from the Administrations show that most of them are still running their suburban services with two classes of compartment. There appears however to be a certain tendency to extend the one class only system. Several Administrations run both one class only services and other services with two classes, and it appears likely that in the near future all their services will be one class only (DSB, PKP).

The basic fares are generally the same for suburban services as for the main lines, i.e. kilometric. This rule is not upset by the fact that certain Administrations responsible for urban services over the same lines as the suburban lines (SNCV, DSB) have special rates for the sections entirely within the urban zone (single tariff in general).

The basis of the tariff remains kilometric in the case of two Administrations who grant reductions on the basic rate for single tickets (CP, 20 % reduction, and PKP 30 % reduction in *GDANSK* only).

Only three Administrations, the TCDD, SNCF and RATP have zonal tariffs completely different from the main line tariffs.

The case is very simple on the TCDD : the suburban traffic is rated according to 4 different distances around each city from which the suburban services start. The same principle is used on the RATP and SNCF, but it is more complex in application owing to the actual structure of the system (existence of lines with many curves, parallel lines (« de rocade », etc.). For the sake of co-ordination, the SNCF tariffs for the Paris suburban services and those of RATP for all its services, road and rail, urban and suburban, have a common basis, which is the price of a bus ticket (U). Leaving aside the question of the RATP urban tariffing, which lies outside the scope of this study, the Parisian region has been « zoned », taking the special difficulties mentioned above into account, and to each zone a multiple of U is attributed which represents the cost of transport by rail from no matter which station in this zone into Paris or vice versa. This price is approximately equivalent to that obtained for the same run by the combination bus + metro.

It should be pointed out that such a tariff system has no connection at all with the general tariff system of the SNCF, and in particular that it is not revised at the same dates as this latter. In fact, the value of U is fixed and revised in such a way as to ensure in principle the financial equilibrium of the RATP.

It is possible therefore to get fairly considerable differences and fluctuations between the basic « main line » tariff and the basic « suburban » tariff, which has led to the provision, on the boundaries of the suburban zone, of certain connecting

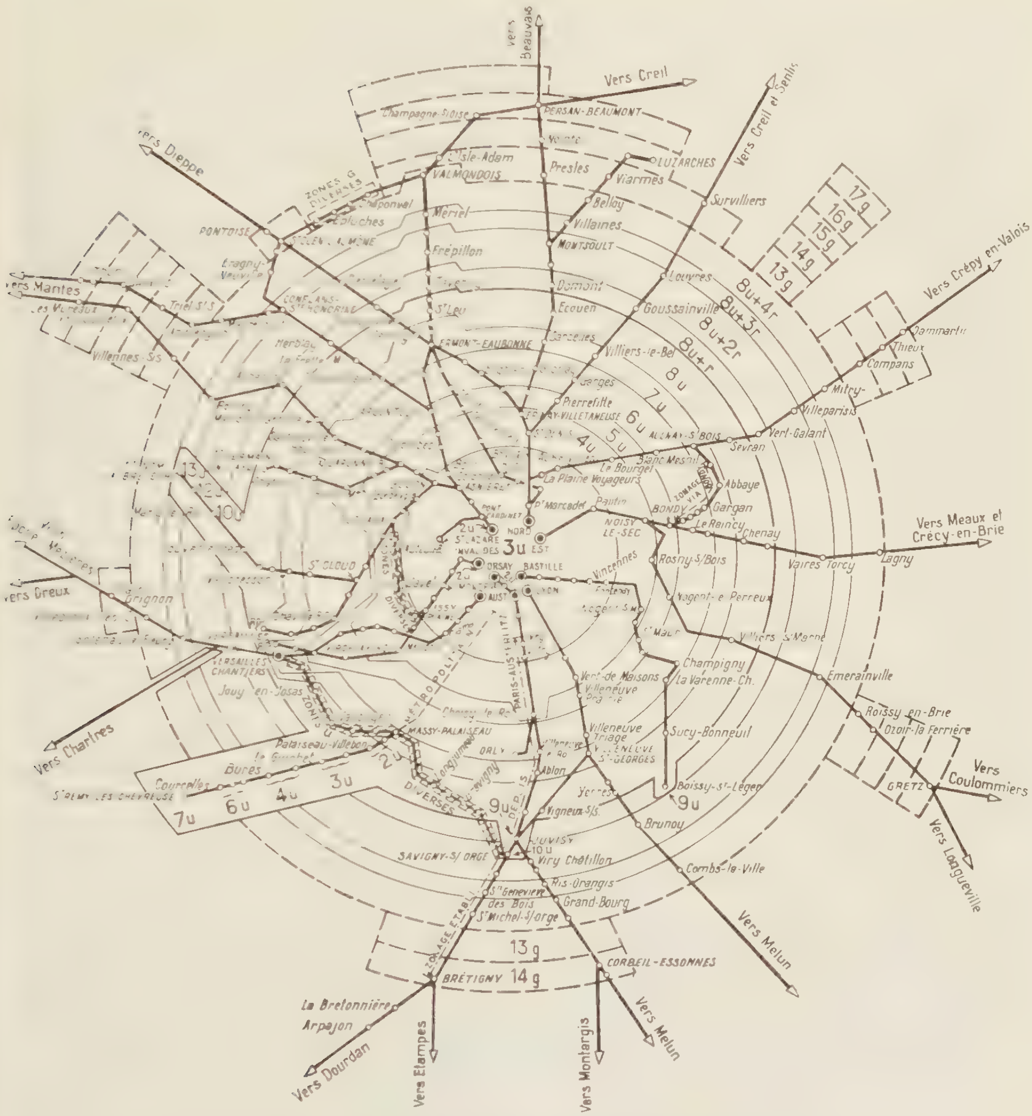


Fig. 18. — Diagram showing the tariff zones of the suburban lines of the Paris region (General tariffing), May 1959.

zones with the « main line » tariffs, as is shown in the diagram of the zonal rates of the Paris region (fig. 18).

All the above refers to the normal rates. Appreciable reductions are generally granted to certain categories of users, either for commercial reasons, or, more often, for social reasons. These necessitate the issuing of weekly, monthly or longer season tickets.

Certain Administrations do not give any

special concessions for season tickets in suburban traffic (CFF, FS, RENFE, for example) whilst others offer season tickets at lower basic rates in their suburban zones than for main line seasons, or use formulas which are not in use for the main line traffic (CP, MAV, SNCF, for example).

Taking an average user of these season tickets, the reduction obtained compared with the basic single fare varies according to the Administrations, and possibly according to the distance involved and the period of validity, from about 50 % to 80 % or even 90 %.

The following table appeared very significant to the Reporter. This table shows in gold centimes the transport rate of the passenger-km in the lower class, for a single 30 km basic journey [1] :

a) with an ordinary « main line » ticket;

b) with an ordinary « suburban traffic » ticket;

c) with a weekly « workman or employee » season ticket in suburban traffic :

This table shows that the basic rate for the suburban services is practically the same as that for the main lines, but that considerable reductions are granted to wage-earners for their regular travelling to work.

These very reduced rates are undoubtedly a public service charge. However, the Administrations who get complete or partial compensation from the State or Community are few in number : only three have admitted this principle to date : Belgium, France and Hungary, representing 5 Administrations (SNCB, SNCV, SNCF, RATP and MAV). In the same order of ideas, the CFF gets a guarantee of minimum receipts from local communities when they ask for new trains at agreed times.

[1] This journey is definitely longer than the average distance passengers are carried in suburban traffic (see chapter 3). When the basic rates decrease with the distance, the figures given in the table are therefore not fully significant. But the choice of a distance of 30 km was by coincidence that chosen as an example by the greater number of Administrations in their replies.

In Belgium and Hungary, it is the State itself which pays for the financial compensation granted to the Administrations for these so-called social tariffs on the suburban services. It would appear that in Hungary there is complete compensation; in Belgium this covers in principle only half the loss of receipts.

In France, the loss of receipts is fully compensated in principle, but on the basis of an average tariff which is lower than the basic tariff, and carried out according to complicated calculations which introduce the idea of the elasticity of the traffic as a function of the tariffs and marginal cost of the additional traffic. The State and the local communities concerned contribute towards paying this compensation in the respective proportions of 70 % and 30 %.

The Reporter, for his part, can only stress the legitimacy of such compensation and remind readers that the underlying principle can be found in the studies concerning the normalisation of the accounts made by the *INTERNATIONAL RAILWAY UNION*.

* * *

7. MANAGEMENT OF THE SUBURBAN SERVICES.

No Administration has entrusted the management of its suburban services to any special Management or Organisation.

The SNCF, however, reports that, owing to the size of the problem, in the case of the Paris region services, one of its Departments (that of the General Studies) has been entrusted with centralizing questions concerning the general organisation of the suburban services within the framework of the general organisation of Parisian transport (programme of capital investment, coordination, economic balance sheets, etc., relations with the official organisation responsible for dealing with these questions) [1].

With this very small exception, the suburban services are run everywhere, and

[1] Which will be dealt with in chapters 8 and 10.

TRANSPORT RATES PER PASSENGER-KILOMETRE IN 2nd CLASS (1) AT THE BEGINNING OF 1961

(for a single journey of 30 km)

In gold centimes

Administration	*Ordinary ticket main lines*	*Ordinary ticket suburban traffic*	*Weekly « workman or employees » season in suburban traffic*
ÖBB	3.9	3.9	(2)
SNCB	5.5	5.5	0.9
SNCV	—	5.7	1.5
DSB	5.2	5.2	1.9
RENFE	2.1	2.1	0.9
RATP (3)	—	4.2	1.4
SNCF	4.9	4.9 (4)	1.3
MAV (5)	3.7	3.7	0.5
FS	3.1	3.1	0.9
PKP	4.0	4.0 (6)	1.2 (6) (7) (8)
CP	3.0	2.4	— (2)
CFF	7.8	7.8	1.0 (6)
TCDD (9)	2.0	0.8	0.2

(1) 3rd class on the RENFE, CP and TCDD. These three Administrations run their suburban services with two classes, 2nd and 3rd.
(2) The information supplied by the Administrations did not enable us to calculate this figure. However, there are season tickets issued at cheaper rates than the fares shown in the previous column.
(3) The RATP suburban system has no 30 km long sections, so the prices shown are the average fares for each category.
(4) Taking into account what was said above concerning the tariffing of the SNCF in the suburban zone, it is a coincidence that at 30 km the suburban tariff equals the main line tariff.
(5) For a single basic journey of 38 km instead of 30 km; the tariff for 30 km would be slightly higher.
(6) This figure is valid for the *WARSAW* suburban zone. In the case of the *GDANSK* suburban zone, the tariff is reduced by 30%.
(7) Monthly season valid for a return journey on each working day, taken as being used for 25 return journeys a month.
(8) The wage earner only pays 1/8th of this fare, the employer paying the other 7/8ths.
(9) For a single journey of 45 km instead of 30. Only the main line ticket is affected, which would be at a slightly higher rate for 30 km.

from every point of view, just like the main line services.

The Reporter would personally like to ask whether it would be judicious to retain this position in the future. In his opinion the problem deserves very careful attention by all Administrations whose suburban traffic forms a large part of their activities (1).

In effect, nearly all the problems raised by the suburban services have a marked specific aspect, whether it be question of the method of operating, of the stock, the tariffs, etc. On the other hand it is easy to appreciate, even when no precise balance sheet is got out, that the sums involved can be very considerable.

At the present time no Administration gets out directly any balance sheet for its suburban traffic from the accountancy details proper to this kind of traffic.

Only the SNCF, RATP and DSB (2) regularly prepare each year a financial balance sheet, either from the statistics making use of the result of calculations of the cost (SNCF), or by direct imputation as far as possible of the costs and receipts, completed by an approximate calculation of the general costs and various receipts (RATP).

The balance sheets got out by these three Administrations for a practically identical period (1959 or 1958-1959) can be given in the following condensed form :

Administration and year in question	*Total receipts gold francs R*	*Total costs gold francs E*	*Operating coefficient E/R*	*Deficit in gold francs E — R*	*Number of PK*	*Deficit per PK in gold centimes*
DSB (1958-1959)	—	—	—	4 365 000	586 900 000	0.74
SNCF (1959)	156 650 000 (*)	209 050 000	1.33	52 400 000	4 540 000 000	1.15
RATP (1959) Sceaux line only	15 425 000 (*)	18 050 000	1.23	2 625 000	385 000 000	0.68

E = Expenditures. . R = Receipts.

(*) Including all subsidies and compensation payments.

Note :

— the amount of the sums in question;

— the existence of a considerable deficit, even in the case of the RATP whose general budget is balanced.

The Reporter would also recall the fact that owing to the method of fixing the suburban tariffs described above on the

(1) Naturally only the advisability of setting up a functional management at General Management level can be considered, the executive services remaining common to all the passenger traffic.

(2) The balance sheets prepared by the DSB only cover the electrified portions of their suburban services, which also include urban services.

SNCF, it is practically impossible for them to balance their « suburban » budget.

It is certainly of very great advantage for the Administrations to prepare such balance sheets in order to guide their own policy and to strengthen their discussions and negotiations with the Public Authorities and Communities (¹).

In particular as it is still exceptional for the State or Local Community to share in the cost of « social » tariffs, it is not surprising to find that they give no assistance towards the cost of suburban services, such as financing certain capital work, granting loans on specially advantageous terms, making sites available, sharring in the cost of the line, whereas negotiations with the Public Authorities, carefully prepared and based on precise and indisputable balance sheets might result in more favourable decisions.

* * *

8. TECHNICAL COORDINATION OF THE SUBURBAN SERVICES OF ADMINISTRATIONS WHO ARE MEMBERS OF IRCA WITH OTHER URBAN AND SUBURBAN RAILWAYS.

Leaving out urban and suburban tramways, which lie outside the scope of this Report, there are often other urban or suburban Railways supplementing the suburban services of the Administrations.

The following table recapitulates, city by city, the information received by the Reporter on this point :

This considerable network of various types of lines can be grouped into three main categories, the two former being generally in the open and the the third underground :

(¹) The method perfected by the U.I.C. is available to assist them in preparing these balance sheets.

Cities	*Kind of line or system*	*Serv ce*	*Length of line or system*	*Annual volume of traffic*	
				10^6P	*10^6PK*
VIENNA . . .	Suburban railway	*VIENNA-BADEN*	33 km	4.1	45.8
BRUSSELS .	The SNCV, member of the I.R.C.A., has a suburban line completing the SNCB line which has been included in this report. Its main characteristics are recalled here.	Various services (see fig. 19)	182 km	44.8	
COPENHAGEN	Suburban railway connecting with the DSB lines at a station in the suburban zone	*JAEGERSBORG* to *NAERUM*	8 km	1.5	–
MADRID . .	Underground metropolitan railway	—			

Cities	Kind of line or system	Service	Length of line or system	Annual volume of traffic	
				10^6P	10^6PK
BARCELONA.	1. Underground metropolitan railway	—	—		—
	2. Various private suburban lines (surface)		—	—	—
PARIS	1. Metropolitan railway, mostly underground, operated by RATP	14 lines which do not extend beyond Paris	169 km	1 170	6 180
	2. The RATP. Member of I.R. C.A., operates a short suburban system (so called Sceaux line) whose characteristics recalled here were taken into account in this Report. Lines in the open except for the urban part	*PARIS* to *ROBINSON* and *MASSY-PALAISEAU*	19 km	45.1	384.7
BUDAPEST. .	1. Suburban railway in the open 2. An underground urban line	Various services	150 km	127 (1)	—
ROME . . .	1. Metropolitan Railway, partly underground (60 %), mixed runs, urban and suburban	—	11 km	12.7	86.1
	2. Various suburban lines in the open	Various services	231 km	18.3	378.4
MILAN . . .	Suburban railway in the open	Various services	233 km	40.7	962.8
TURIN . . .	Suburban railway in the open	Various services	100 km	4.9	114.1
NAPLES . . .	Suburban railway in the open	Various services	197 km	58.0	742.3
LISBON . . .	1. Metropolitan railway under construction	—	—	—	—
	2. Suburban line in the open	*LISBON-CASCAIS*	26 km	21.2 (2)	—
ZURICH . . .	Urban and suburban lines in the open belonging to various companies and not connected together	Various services, one starting in a CFF station in the suburban zone (see fig. 20)	—	6.7	—

(1) This line also carried 798 000 tons of goods in 1960.

(2) This line also carried 36 000 tons of goods in 1959.

1. networks or isolated lines for suburban transport radiating around the cities, two diagrams of which are appended for *BRUSSELS* and *ZURICH* (fig. 19 and 20). These networks are of considerable size and sometimes carry goods traffic.

2. isolated lines branching off at one of the suburban stations on one of the lines of the main Administration.

3. urban metropolitan lines, amongst which the Paris metro is far and away the largest.

The technical connections between these urban and suburban networks and the lines

Fig. 19. — Diagram of the railway network of the SNCV in the suburban zone of Brussels.

Legend : SNCV lines.
common sections with urban tramways.
SNCB lines.

of the Administrations are as a rule assured in the case of lines coming within the two last categories, but are the exception in the case of lines and networks in the first category.

The only two examples reported by the Administrations in this category are in fact an interesting case of interpenetration and the common user of the terminus station. Technical connection is therefore complete.

Fig. 20. — Diagram of the suburban lines of Zürich region (CFF and private companies).

Legend : CFF lines.
Private lines.
Stations.

This relates to the *TURIN-RIVAROLO* and *NAPLES-BENEVENTO* lines, operated by private companies, which have agreements with the FS, so that their trains run

into the FS stations of *TURIN-PS* and *NAPLES CENTRAL* after running over FS lines for some 20 km.

This solution, which is particularly judicious and satisfactory from the users' point of view, presupposes, however, a large number of passengers and the interpenetration on the main line must not be unduly long compared with the total length of the run.

In all the concrete examples of lines of the 2nd category given by the Administrations, these conditions were not fulfilled. This meant there had to be transhipment at the junction stations. This however is a very simple operation. The connections are usually on the same level for one direction, passengers using an underground passage or footbridge for the other direction. The volume of exchanges being limited, the output capacity of the connecting installations is much greater than actual requirements, and looks like being so for many years to come

So called « metropolitan » railways on the other hand give rise to special problems as regards technical connections with the systems of the Administrations. As has already been said, such connections have usually been arranged, but in some cases there are none, especially when the system has not yet been finally completed. The *LISBON* Metro for example has as yet no connecting point with the CP system; in the future it will run services to the most important of this Administration's stations. Likewise, in *MILAN*, the FS stations are not linked up with the first lines of the metropolitan which are soon to be inaugurated.

The public and the Administrations have the greatest interest in good technical connections between the metro and suburban stations, so it is to be hoped that such situations are only temporary.

In *ROME, MADRID* and *BARCELONA*, the stations of the Administration and platforms of the metro are directly connected by means of passages. It appears that this is sufficient and satisfactory, but the Administrations did not give any precise details on this subject, so that the question can only be gone into in detail in the case of *PARIS*. Here the connections between the SNCF stations and the metropolitan network operated by RATP are assured at all the terminal stations of the SNCF suburban lines : Paris-Est (3 metro lines), Paris-Nord (2 lines), Paris-Saint-Lazare (3 lines), Paris-Montparnasse (4 lines), Paris-Lyons (1 line), Paris-Bastille (3 lines), Paris-Orsay (1 line).

Two intermediate stations in Paris also have such connections :

Paris-Austerlitz (1) (2 lines);

Paris-Saint-Michel (1 line).

The actual arrangements at each station are obviously made individually; the following table shows, for the Gare Saint-

(1) Paris-Austerlitz is a main line terminus. In the case of the suburban services, it is simply a through station for lines which start at Paris-Orsay.

From	*Horizontal distance*	*Difference in level vertically*
The platforms of Metro. line No. 3	105 m	7.50 m
From the platforms of Metro. line No. 12	165 m	10.50 m
From the platforms of Metro. line No. 13	145 m	11.70 m

Lazare, the horizontal and vertical distances to be covered between the platforms of the metro and the premises of the SNCF station.

Figure 21 is a detailed plan showing the whole of the Metropolitan installations at the Gare Saint-Lazare.

In this particular case, the changes in level to the SNCF station are made by means of sloping passages or by fixed stairways. In other cases, at Paris-Nord for example, certain changes in level are made by means of escalators. The extension of such equipment, which is being regularly done, is limited at the present time to means of overcoming changes in level. The horizontal distances are moreover nearly always very small, 150 m being almost the maximum. However, at Montparnasse station, owing to two formerly separate metropolitan stations being connected, the horizontal distance in the connecting passages may be as much as several hundred metres. In this particular case, the installation of a conveyor is being considered.

There is a considerable exchange of traffic between the Metropolitan and the SNCF, which shows very clearly the resources the two railways, one urban, the other suburban, in close technical connection, can offer as regards the dispersal and concentration of masses of passengers. The following table shows for the main stations, from counts made during January 1961, of season ticket holders, the approximate number of suburban passengers changing from one railway to the other, on the one hand, the daily average, and on the other at the rush hours (see following Table).

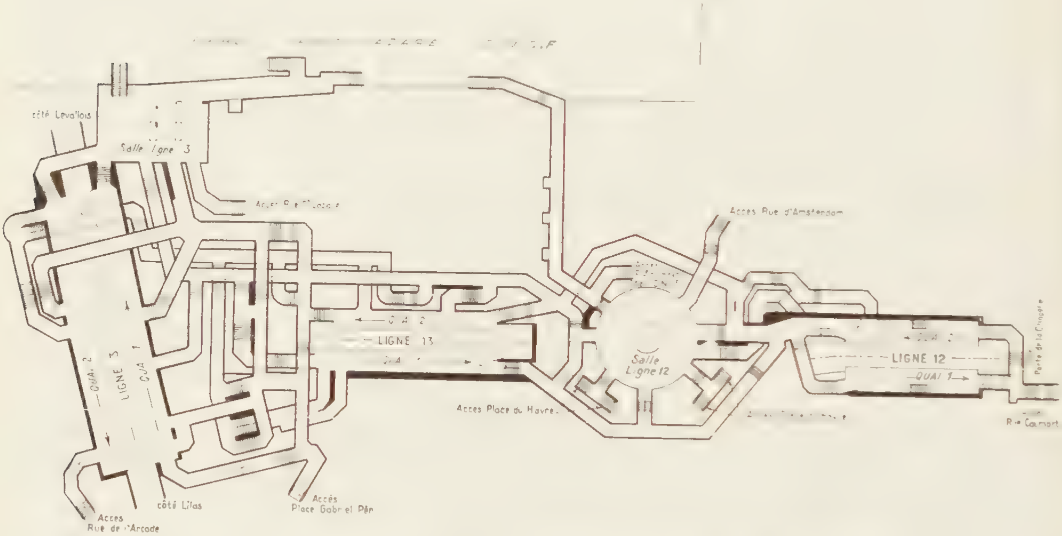


Fig. 21. — Paris Metro. Plan of access to St-Lazare station showing different technical means of connection with the SNCF station.

There is a case of a connecting station on the RATP between its urban Metropolitan system and its Sceaux suburban line. The exchange traffic at this common point (Denfert station) is some 70 000 passengers daily, with 8 500 to 9 000 at the rush hour. To deal with such traffic, special arrangements had to be made.

At Paris-Nord, where it is expected that the traffic will double itself within 10 years, each suburban passenger platform has a direct connection with the Metropolitan passage ways.

Station	*Number of suburban passengers exchanged between SNCF and RATP (Metropolitan)*	
	daily average	*at rush hours*
Paris-Lyons (only 1 Metro line)	57 000	13 500
Paris-Austerlitz (2 Metro lines)	65 000	14 500
Paris-Nord (2 Metro lines)	96 000	25 500
Paris-St-Lazare (3 Metro lines)	145 000	31 000

At Paris-Saint-Lazare, where 6 SNCF suburban lines converge with 3 Metro lines, the installations are practically used to full capacity already. There would be no point in increasing the output of the connecting passages as these correspond more or less to the maximum traffic which the Metro can take away. The only solution recognised as possible would be to reduce the traffic at this station by making direct connections with some of the lines to a new underground transversal line (fig. 22).

From the results of the above mentioned count, it would appear that the proportion of suburban passengers who after arriving at the station make use of some other means of transport (other than walking) to reach their final destination in Paris is very small, only 10 to 15 % according to the station.

Nevertheless the presence of large railway stations right in the heart of the city of Paris has often been criticised by the town planners who object that :

— they occupy valuable space;

— they cut a certain number of through roads;

— they lead to heavy concentrations of traffic and thus cause traffic jams.

Such criticisms are not levelled at Paris alone; the SNCB, RENFE, FS, and MAV all report that their terminus stations in the large cities have been the subject of similar criticisms, more particularly as regards the interference with through roads.

On the other hand, other Administrations (DSB, PKP, CFF) state that they have never been criticised in this way.

A few transfers or improvements in the position have been made in some countries (Belgium, Italy). The State has been largely responsible for financing the work, whilst there has been close collaboration between the Railway, the local Administrations and the Urban Councils, who on their side have rearranged the sewers and the town traffic in such a way as to ensure that the services to the new stations shall be as satisfactory as possible. It should be noted that in no case has there been any refusal to allow stations outside the city or even on its periphery.

In Brussels, the station concerned (Brus-

sels-Midi) has practically not been moved, but all the lines have been raised 7 to 8 m, which enabled to make numerous passages under them, thus restoring the through routes formerly interrupted and doing away with the main grounds for criticism of the town people. This operation was combined

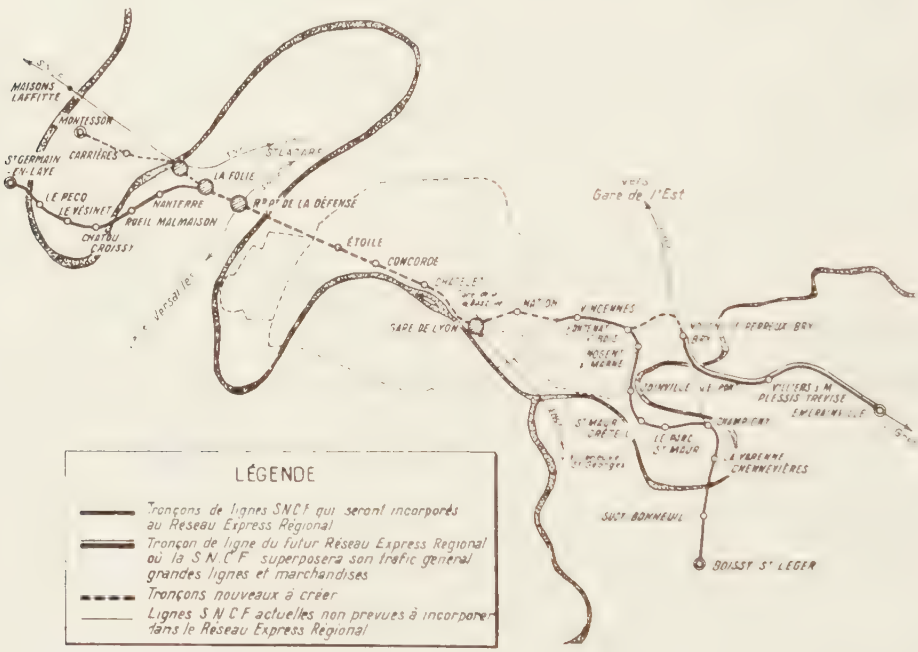


Fig. 22. — Project for the first line (East to West) of the future Regional Express Network of the Paris region.

Legend : Sections of SNCF lines to be incorporated in the Regional Express network.
Sections of the future Regional Express Network to be used by the SNCF for its general main line and goods traffic.
- - - - - New sections to be built.
——— Existing SNCF lines which will not be incorporated in the Regional Express Network.

with the making of a connection between the Nord and Midi Stations, the connection which passes through the city being built either as a viaduct or underground, and a station has been built on the lines of this junction, right in the centre of Brussels, which handles a traffic of more than 50 000 passengers a day.

In Italy, on the occasion of work of reconstruction or modification, the stations of *MILAN PORTA NUOVA* and *NAPLES CENTRAL* have been moved a little from their old positions, in full agreement with the two planning departments of the local Administrations. In addition, underground roadways have been built under the access lines, so that there was no longer any question of moving the stations out of the city or to its boundaries.

Finally, in Rome the new *TERMINI* Station takes all the lines which formerly ended at various city stations. This station is a bare kilometre from the centre of Rome, and its construction was the subject of a town planning project got out by the FS and the State and City of Rome authorities, and its successful outcome has been

much appreciated by all visitors to the Italian capital.

The Administrations are in general very much against moving their terminal stations outside the cities or to their boundaries, for reasons which have been formulated very well by the NS :

« On the commercial plane, stations within the city enable clients to complete their journeys in a shorter overall time and under better conditions; as far as town planning is concerned, they involve less traffic from the periphery towards the centre; the terminal passenger traffic takes place all at once and not at stepped out intervals, and many of the passengers are so close to their final destinations, that they complete their journey on foot. »

Owing to the large capital sums such changes would involve (since, as a general rule, the new passenger stations would have to be built on the site of the goods installations which themselves would first of all have to be moved somewhere else), such radical projects have little chance of being realised. This is the real reason why certain projects of this kind put forward by the Paris town planning authorities for certain SNCF stations have never been seriously considered.

Belgian and Italian experiences show, however, when there exist real problems, it is generally possible to find solutions which will satisfy both the requirements of all the urban traffic and the legitimate desire of the Administrations to have their stations right inside the large cities.

From the financial point of view, the position of the Administrations should logically be : the railway should only have to find the capital for costs corresponding to an effective increase in its installations which it wants, and for financing operating changes which will eventually lead to economies thanks to the new arrangements adopted.

* * *

The facts reported in this chapter, devoted especially to the problem of coordination between the suburban lines of the Administrations and those of other urban or suburban systems have shown that in many towns, there are problems of this kind and that they may be serious. Relations between the Administrations and other networks are numerous and most satisfactory. Two examples of perfect technical coordination were reported in particular from Italy thanks to agreements for common user and interpenetration made between the FS and private companies. Interpenetration presupposes, as we have seen, a certain number of conditions that are rarely fulfilled. The Administrations mention in their replies only another examples : in Brussels, the SNCV takes its passengers right into the centre of the city, thanks to agreements made with the urban tramways company on four terminal routes. Agreements of the same kind will be made at the appropriate time between the SNCF and the Company responsible for operating the new Regional Express Network for the common user of a 23 km section.

However, the seriousness of the problems arising in the large cities leads to a fer that the collaboration between the various transport undertakings will be insufficient to regulate all the problems of technical coordination, which often have vast implications right outside their normal fields of activity. A case in point is the question of moving the terminal stations in the large cities. This involves the question of expediency and the existence of organisations responsible for elaborating the future programme of suburban transport as a whole and deciding upon the different stages, organisations in whose work the Administrations must obviously be closely associated.

The problems of suburban transport in certain cities are considered as not great enough for such organisations to be needed, so that it is not surprising that the replies received from the Administrations show that there has not been any question of setting up such organisations.

On the other hand, certain Administrations report the existence of more or less

extensive land tribunals or technical commissions (RENFE, MAV, CFF) to meet such requirements in the cities concerned. Extensions in the powers of the creation of new organisations with greater powers are sometimes under consideration. The DSB on the contrary reports that a proposed law to create such an organisation in *COPENHAGEN* with extensive powers was thrown out by Parliament.

In the case of the transport in the Paris region, there is a « Syndicate of Parisian Transports », an organisation set up in 1959 by the State, the City of Paris and the 4 departments geographically concerned in the problem of transport in the Paris region. The actions of this syndicate are concerned above all with tariff and commercial coordination, to be dealt with in chapter 10. But they are also responsible for keeping a close watch on development projects in connection with the means of transport in the Paris region.

The project now under study covers the four year period 1962-1965; it provides for the commencement of the construction of the first line of an electric network for transport over medium distances known as the regional express network, to be formed by connecting together a certain number of the SNCF suburban lines by means of underground links through Paris. The underground sections will have an improved layout compared with the present metro so that SNCF type trains can run on them at a speed of 100 km/h. There will only be a limited number of stops in Paris: these will assure the connections with the most important junctions of the Metropolitan railway.

The general structure of the regional express network is still far from being finally settled, but it is expected to consist essentially of two important cross lines, one east to west, which will be built during the 1962-1972 period and the other north to south (fig. 22).

The project now being studied also provides for the SNCF to extend the electrification of its suburban lines and to make certain important modifications in certain Paris stations, which will be necessary on account of the increased traffic expected, which have been dealt with in Chapter 5.

It is clear that problem of this magnitude can only be approached by investigations and projects far beyond the means of the Administrations: in such complicated cases, the setting up of organisations with more extensive powers, embracing in addition to the Administrations, all the Departments and Communities concerned, is absolutely essential.

* * *

9. TECHNICAL COORDINATION BETWEEN THE « MAIN LINE » SERVICES AND THE SUBURBAN AND URBAN RAILWAY SERVICES.

Exchanges between the urban and suburban services and those of the main lines have not been counted by the Administrations, so that it is not possible to characterize them accurately. The Reporter therefore regrets that he can only make general statements and estimates which merely reflect his personal judgment.

Compared with the volume of traffic affected by exchanges between suburban services and urban services, it is quite clear that the exchange traffic covered by this chapter cannot be said to be important.

A distinction can however be made between exchanges between suburban services and main line services and those between urban services and the main lines: the former are without doubt of little importance compared with each of the two traffics in question, whereas the second, though they may be of very little importance compared with the sum total of exchanges with the urban services may be significant in relation to the main line traffic.

Such exchanges have not necessitated any special installations in the stations in any case, even when the suburban services and the main line services are worked on different lines and platforms. The arrangements that have to be made in any case

to deal with passengers coming in from outside are suitable and adequate for passengers changing from one to the other, whether it is question of a terminus station or through station. Likewise the technical means of connection between the urban services such as the metropolitan railways and the stations of the Administrations are suitable for passengers of both the main lines and suburban trains.

The terminus stations have almost a monopoly of the exchanges between the urban services and main lines services; they also are responsible for a great proportion of the exchanges between the suburban traffic and main line traffic. However, it often happens that there are stations on the outskirts of the suburban zone at which some of the main line trains stop thus allowing of exchanges of passengers between these two categories of traffic; sometimes this happens within the suburban zone, if this is very extensive or when it includes important railway junctions, at which the main line trains stop (SNCB, SNCF, DSB, CFF, FS).

* * *

10. FINANCIAL AND COMMERCIAL COORDINATION WITH METROPOLITAN AND OTHER RAILWAYS.

In Chapter 8, we dealt with the organisations that have been set up in various countries, with more or less extensive powers, in order to achieve technical coordination between the Administrations and the urban and suburban networks, especially from the point of view of their development programmes.

Tariff, commercial, and possibly financial coordination is more easily obtainable by direct agreements between such railways and the Administrations in all cases that are not of undue complexity.

It is therefore not surprising to find that there is no official organisation for this purpose outside France, where at the present time such responsibilities are entrusted to the Syndicate of Parisian Transports. But although this Syndicate has only been in existence since 1959, a similar organisation for the same purpose has been in fact in existence since 1938 under various names. In particular, the Committee of Parisian Transports was responsible for the tariffs on common bases for the SNCF and RATP in force since 1941, dealt with in Chapter 6 above.

On the financial plane, the creation of this Syndicate standardised the regulations for the distribution of payments made to the SNCF and RATP for loss of receipts due to the application of the reduced fares they are required to offer for social reasons (see Chapter 6 above).

In future, 70 % of this compensation will be paid by the State and 30 % by the Community, whereas up to the present different rules have applied to the SNCF on the one hand and RATP on the other.

The Syndicate is therefore the organisation responsible for Paris transport as a whole; it has powers to assure that this is worked at the lowest cost to the Community as a whole.

The tariff agreement between the SNCF and the RATP for its suburban services has been commented upon in Chapter 6 above. This is practically a unique case : the only other example mentioned in any of the replies is that of the three suburban lines of the Zurich region who have adopted tariffs like those of the CFF. Each Company in question has estimated the « tariff kilometrage » of its line, which might differ from the real kilometrage, and the CFF tariff is applicable to this tariff kilometrage for ordinary tickets. One of the Companies also has the same tariff for season tickets as the CFF.

If examples of common tariffs are rare, the issuing of combined tickets or season tickets is more frequent.

Examples of this were reported by the SNCB, SNCF, DSB and CFF. The SNCF also reports that it sells RATP season tickets at its suburban stations, but these are not actually combined season tickets. The CFF, in addition to various classic examples,

reports one fairly exceptional case : the holder of a season ticket for all their lines also receives a card entitling him to free travel on the urban transport services of 17 Swiss towns. This facility is made possible thanks to the Union of Swiss Transport Undertakings, an organisation which is also a member of the IRCA.

Cooperation between transporters also extends to the goods traffic when technical characteristics such as the gauge, loading gauge, radius of curves, transitions, etc., so allow. The ÖBB, SNCF, FS, and CFF all report movements of goods wagons over the suburban networks connected to their installations (but not with the metropolitan networks where satisfactory technical conditions are impossible).

In every case the traction is assured by the Administration operating the line. The tariffs are either those for private sidings (FS) or dividied pro rate to the distances (ÖBB) or according to special agreements for through traffic (CFF).

In the case of the SNCF, this traffic is worked in conjunction with RATP; it is forwarded over a line under a rather complicated regime, which will shortly be standardised as already reported.

The SNCF receives all the receipts, and pays RATP its various charges according to the rates laid down by contract.

On the other hand, there are no examples of financial solidarity between the different transport undertakings, no matter how closely they are connected in the field of the tariffs or for carrying out certain services in common.

* * *

II. SUMMARIES.

Although it is often important as regards the receipts, costs and capital investments represented, the suburban traffic only represents a small part of their activities for most Administrations. For this reason, it is to be feared that they have not always paid sufficient attention to it. However, the problems it gives rise to are of a very special nature, quite distinct from those of the main lines, and it is of great interest to study them specially. The enquiry which led to the compiling of the present report has confirmed this.

It is not sufficiently complete to allow the final summaries to be formulated — only the special report will make this possible, but it has made it possible to throw some light on this difficult question, which can be summed up in the following provisional summaries :

I. — Suburban traffic is characterized by the daily movement in alternate directions of wage earners, scholars and students to the large centres; the greater part of this traffic consists of travel in radial directions. The regularity of the journeys made by each individual and the social status of the passengers distinguishes this traffic from that due over a wider zone of attraction to the existence of a large city playing the part of an economic metropolis. Nevertheless, in the case of journeys which begin within the suburban zone properly speaking, these two kinds of traffic are superimposed and cannot be separated in practice, though the former preponderates and gives its own particular traits to the whole.

II. — The demand for suburban transport is characterized :

a) by the very great number of passengers, making a short average journey, about 12 to 18 km:

b) by its high concentration, making it necessary to have many stops very close together;

c) by fluctuations in time, the greater the smaller the period considered : seasonal variations are only noticeable in certain countries where the rythm of work is profoundly affected by certain customs, such as the concentration of holidays within a short summer period; weekly variations are considerable everywhere, with Sunday traffic — and increasing Saturday traffic — very much smaller than that of an ordinary day of the week; daily fluctuations are

also considerable, the rush hour traffic often being as much as 15 to 20 times greater than that of the slack periods, with no demand at all for 4 or 5 hours every night;

d) by a fairly general tendency to increase, with a greater increase than ever in the rush hour traffic, if things are allowed to go their own way;

e) by the need for very low transport rates;

f) by important exchanges, especially in the very large cities, where urban transport facilities are available, especially metropolitan railways, and few but still considerable exchanges with the main line services, and other connecting suburban services.

III. — The technical means and operating methods have had to be adapted to these particular aspects of the demand, sometimes giving the suburban services the character of a repeated daily performance less well known to the general public but just as indisputable as that which markes the operating of the main line services :

a) the rolling stock in particular is often specially designed for suburban traffic. This is the case for example with the reversible electric rail motor coach sets. Even when the traction is assured by classic locomotives, the coaches generally have specially designed, more numerous and wider doors than the standard coaches, and the possibility of being able to drive them in reverse adds great flexibility to the operating;

b) the timetables for the suburban services give rise to special problems to the experts. If circumstances permit, the optimum results are obtained by very characteristic methods of operating : spaced parallel services, or services by zones, according to the nature of the problems. However, the working of various kinds of traffic over the same lines often makes it necessary to be content to make the most with great ingenuity of the lines that are free for the suburban services and to work these in-between the irregularly times through, semi-through and stopping trains;

c) the enormous range of hourly fluctuations in the traffic affects not only the number and type of trains made available, but also the composition of the sets;

d) in the terminus stations, the suburban traffic can be assured, if it is not too great, on the lines and platforms also used for the main line traffic. There is however a tendency to work it a priori from certain designated lines and platforms. After a certain traffic level (about 12 000 to 15 000 passengers per line per hour at the rush hour), in practice it becomes necessary to reserve not only platforms but also main lines for the suburban traffic;

e) the basic tariff for the suburban services is generally identical or at least very similar to that for the main lines. But only a small number of passengers are carried on this tariff, since big reductions of as much as 50 to 90 % (average about 70 %) are granted on weekly or monthly seasons to anyone who makes a regular return journey in the suburban zone. These seasons tickets, granted for social reasons, usually at the request of the Public Authorities, represent a great loss of revenue for the operators, who only exceptionally receive any compensation;

f) the installations for connections between the suburban lines of third parties and the suburban lines of the Administrations are in general very simple; the connections between the main lines and suburban lines of the Administrations are assured without any special installations in the terminus stations and at some of the large stations in the suburban zone. On the other hand, the installations for the technical connection between the urban transport networks such as metropolitan railways and the terminus stations of the suburban lines of the Administrations may be very extensive. These consist essentially of underground passages, sloping passages, stairways, escalators, etc. Their output is considerable and makes it possible to exchange a great deal of traffic (more than 10 000 persons an hour per metropolitan line);

g) ticket collecting in the case of suburban traffic raises very special difficulties.

IV. — In spite of the great deal of skill with which it is assured, the suburban traffic continues to set the Administrations interesting and difficult questions. Some of these are of a technical nature, other more general in their scope. Often, they have only been dealt with in this report from the bases of a very restricted number of replies. It would appear therefore that such questions should be the subject of careful examination during the 18th Session of the Congress.

The Special Reporter, in particular, would then have more opinions and decisions which would enable him without doubt to suggest interesting resolutions on this subject.

The questions which the Reporter would like to submit for special attention are the following :

— is traction by classic type Diesel locomotives an acceptable final solution for suburban services with stops at frequent intervals requiring great acceleration ?

— are high platforms particularly well adapted for suburban lines; are they compatible with the other traffics ?

— is it to the interest of the Administrations to set up parking sites near their suburban stations, and how are they to do so ?

— what steps should the Administrations take to spread out the rush hour traffic ?

— have the Administrations an interest in transferring to other transport undertakings the urban and suburban traffic of the first stations out of the city ?

— is the principle of compensation for loss of revenue due to the « social » tariffs applied to suburban season tickets unanimously agreed ? Why are the results recorded to date still so poor ?

— is the preparation of balance sheets for the operating of the suburban services to be recommended, and on what lines ? Would such balance sheets be likely to facilitate negotiations between the Administrations and Public Authorities in order to obtain compensation for the loss of revenue due to the social tariffs ?

— is the future creation advisable, and if so, when, of a special department, forming part of the General Management, responsible for all matters of principle in connection with the suburban traffic ?

— removing the large railway stations to the boundaries or outside the cities being rejected in principle, under what conditions — and in particular under what financial conditions — should the Administrations consent to the limited transference of some of the large terminus stations ?

— do the Administrations wish to set up technical and tariffary coordination organisations, and if so, with what powers ?

[625 .25]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

18th SESSION (MUNICH, 1962).

QUESTION 3.

Latest developments in the braking of railway rolling stock (systems, control, types of equipment, materials used...).

REPORT

(America (North and South), Australia, Burma, Ceylon, Egypt, Finland, Ghana India, Indonesia, Irak, Iran, Republic of Ireland, Japan, Malaysia, New Zealand, Norway, Pakistan, Philippines, Siam, South Africa, Sudan, Sweden, Union of Socialist Soviet Republics, United Kingdom of Great Britain and Northern Ireland and dependent overseas territories),

by V.M. Kazarinov,

Doctor of Technical Sciences, Professor of the All-Union Scientific Research Railway Transport Institute. Ministry of Communications, U.S.S.R.

Introduction.

During recent years there has been noted on a number of railways a tendency of increasing the speed of passenger trains and the weight of goods trains.

In this connection, naturally, attention is being paid to the improvement of braking systems as a means of ensuring the safety of train operation.

The following principal trends in the perfection of railway brake equipment during recent years may be set forth upon analysing the materials submitted by the railway administrations, as well as publicated materials.

1) The improvement of the brake system air distributing valves in the part of increasing the speed of propagation of the braking wave, increasing the sensitivity of operation upon application and releasing of the brakes, prolonging the periods between repairs, simplifying the design and improving the reliability and stability of action in operation conditions.

2) The increasing of the specific braking force of the rolling stock by using special governors that automatically regulate the force applied to iron brake shoes depending upon the speed of the train, or by employing new friction materials for the brake shoes that have a friction coefficient which only slightly depend upon the speed.

3) The development of special governors that automatically change the braking force of a vehicle depending upon its load or the number of passengers.

4) The investigation of ways of using to the greatest extent the adhesion of the wheels to the rails when braking simultaneously protecting the wheels against slipping upon application of the brakes (anti-slipping governors, electromagnetic rail brakes, mechanical and chemical cleaning of various dirt and atmospheric precipitation from the rail surfaces).

5) The increasing of the extent of employing electric braking on electric loco-

motives and electric trains as an auxiliary operative system in addition to the main friction brakes.

On a number of railways the development has been furthered of the electropneumatic type of automatic brakes, which is the most perfectly controlled system of braking, distinguished as a rule for its quick action and smooth application.

land, Australia and other countries the employment of composition brake shoes with a friction coefficient that only slightly depends upon the speed and with an increased resistance to wear in comparison with cast iron brake shoes is being given increased attention.

These brake shoes permit increasing to a considerable degree the brake efficiency

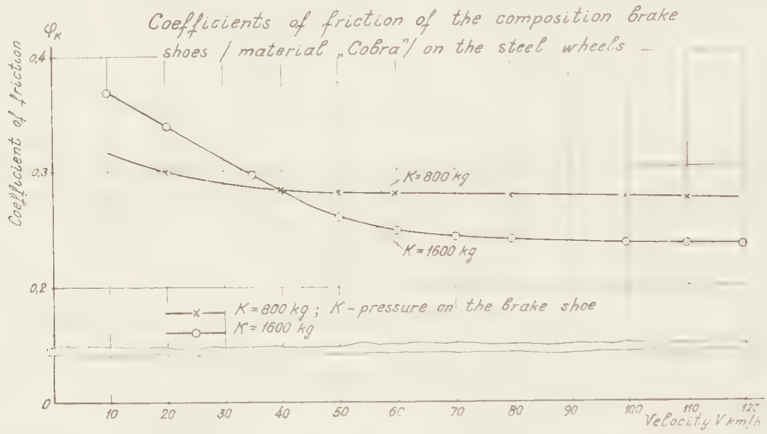


Fig. 1. — Friction coefficient of type « Cobra » brake shoes in relation to train speed.

In connection with the running on some railways of long and heavy goods trains (weighing up to 6 000-8 000 tons and about 1 200 m long) the problem of reducing the longitudinal forces acting in a train upon application of the brakes has become quite important. This problem is solved by employing electropneumatic braking, selecting the proper indicator diagram for the brake cylinders of the vehicles and the locomotives and selecting the characteristics of the relationship of the brake shoe coefficient of friction.

Let us consider briefly some new solutions of automatic brake equipment problems that have been developed during the last few years.

New friction materials for brake shoes.

During the last few years on the railways of England, the U.S.A., the U.S.S.R., Fin-

on rolling stock operated at high speeds without employing special automatic braking force regulators that are dependent on the train speed, simultaneously reducing the force acting on the brake shoes several times.

The most characteristic types of the brake shoes mentioned above are the type « Ferodo VG-4 » shoes (England), the « Cobra » shoes (U.S.A. railways) and shoes of the material 6 KB-10 (U.S.S.R. railways).

Curves characterizing the values of the coefficient of friction for the « Cobra » brake shoes are shown in figure 1, while similar curves for the type 6 KB-10 shoes are shown in figure 2.

Usually such brake shoes, including the « Cobra » and 6 KB-10 types, are manufactured by pressing the friction material onto special steel holders. A general view of such a shoe is shown in figure 3. By

correspondingly selecting the materials a shoe is obtained that has a coefficient of friction only slightly depending upon the speed and a high resistance to wear. Thus, for instance, the 6 KB-10 shoes manufactured on a rubber binder have a wear resistance about 5 times greater than that of the standard brake shoes.

When non-metallic brakes shoes are being used a very great importance should be attached to the thermal influence of these shoes on the wheels and on the wear of their rolling surfaces, as these shoes are not able to remove heat during application of the brakes to the same extent as iron brake shoes do.

The experience obtained in the use of such brake shoes shows that some non-metallic friction materials, while possessing satisfactory properties as regards the value of the friction coefficient and wear resistance, may have a harmful influence on the wheels in respect to the formation of thermal microcracks and cause abnormal wear of the rolling surface of the wheels. Large-scale testing in operation has shown that composition brake shoes of the « Cobra » or 6 KB-10 types do not have the drawbacks stated above.

According to data of the firm « Ferodo Limited » brake shoes of the material « Ferodo VG-4 », consisting in the main of a

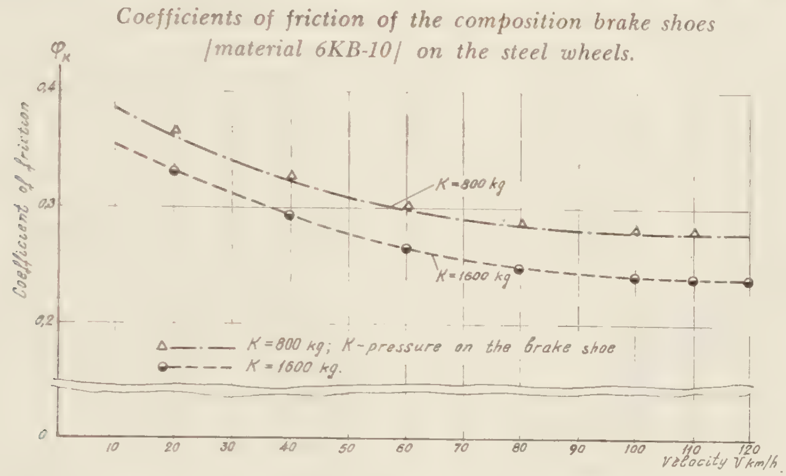


Fig. 2. — Friction coefficient of type 6 KB-10 brake shoe in relation to train speed.

Fig. 3. — Composition brake shoe.

formaldehyde resin and an asbestos filler have a number of advantages over cast iron brake shoes. The firm indicates (and this

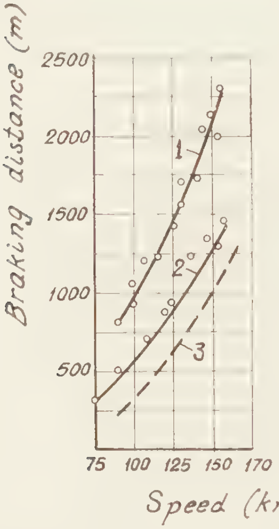


Fig. 4. — Curves showing the relationship of the braking distance (S_m) to the speed of a test train for the following brake shoes.

1) cast iron (coefficient of brake pressure $\delta = 0.48$);
2) of material 6 KB-10 ($\delta = 0.24$);
3) of material 6 KB-10 (calculated for electropneumatic brakes and anti-sliding regulators).

is confirmed to a definite degree by communications of the railways of Great Britain, Australia, Finland, etc.) that these brake shoes have a wear resistance from 3 to 4 times greater than that of cast iron brake shoes. As a result of an increased friction coefficient that depends only to a slight extent on the speed it is possible to considerably reduce the braking distance of high-speed trains with a lighter brake system. Attention is paid to the absence of noise and the smoothness of brake application with these shoes. It has been noted, however, on the railways of Finland, that when using the « Ferodo VG-4 » type of brake shoes in winter during snowstorms a certain reduction of the friction coefficient takes place, which is accompanied by a corresponding increase in the braking distance.

The type 6 KB-10 brake shoes, besides widespread checking in operation on passenger and goods trains on the U.S.S.R. railways, including steep and long downgrades, and also under winter conditions, have been checked for the efficiency of braking at high speeds. Figure 4 shows a diagram of the relationship of the braking distance to the speed of a passenger train and figure 5 shows a similar relationship for a single diesel locomotive, both diagrams being based on experimental data obtained on level sections of track. An analysis of these diagrams shows that as a result of replacing cast iron brake shoes with type 6 KB-10 composition ones and with the pressure acting on the shoes cut in half the braking distance at speeds of from 140 to 150 km/h is reduced by about 40 %.

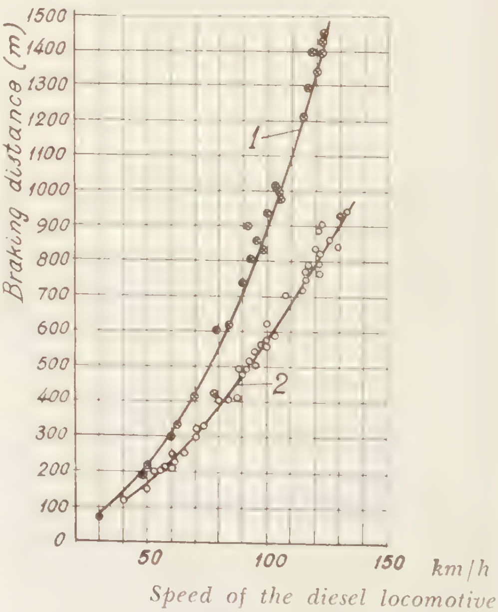


Fig. 5. — Curves showing the braking distances of a type TЭ 7 diesel locomotive unit with the following brake shoes.

1) iron ($P_{br.cyl.} = 3.6$ atm.);
2) of material 6 KB-10 ($P_{br.cyl.} = 1.1$ atm.).

The coefficient of friction for brake shoes of the 6 KB-10 material can be determined according to the following empirical formula :

$$\varphi_K = 0.44 \frac{K + 20}{4K + 20} \times \frac{V + 150}{2V + 150}$$

where :

φ_K is the coefficient of friction;

K is the force acting on the brake shoe in tons;

V is the speed of the train in kilometre per hour.

Electropneumatic brakes.

Electropneumatic brakes are already being used to a great extent on suburban electric trains on the railways of Great Britain, the U.S.S.R., Finland, etc. Various designs of these brakes are in use, with various schematic diagrams, however, they are all much better controlled and more effective than purely pneumatic brakes, even of the newest systems. As regards the use of electropneumatic brakes in long-distance passenger trains and especially in goods trains, in most countries sufficient experience has not yet been accumulated. As can be seen from a scrutiny of the materials received from the various railway administrations, the U.S.S.R. railways have accumulated the greatest experience in the investigation and operation of electropneumatic brakes.

In this connection we shall consider in brief two varieties of electropneumatic brakes employed on these railways.

a) *For passenger trains hauled by locomotives.*

The electropneumatic brake is mounted on the locomotives and the cars, while retaining the existing pneumatic brake equipment. In the general system of brake equipment of a passenger train the electropneumatic brake is the main one and the pneumatic brake — a reserve one which automatically begins to function in case of a fault in the electropneumatic system.

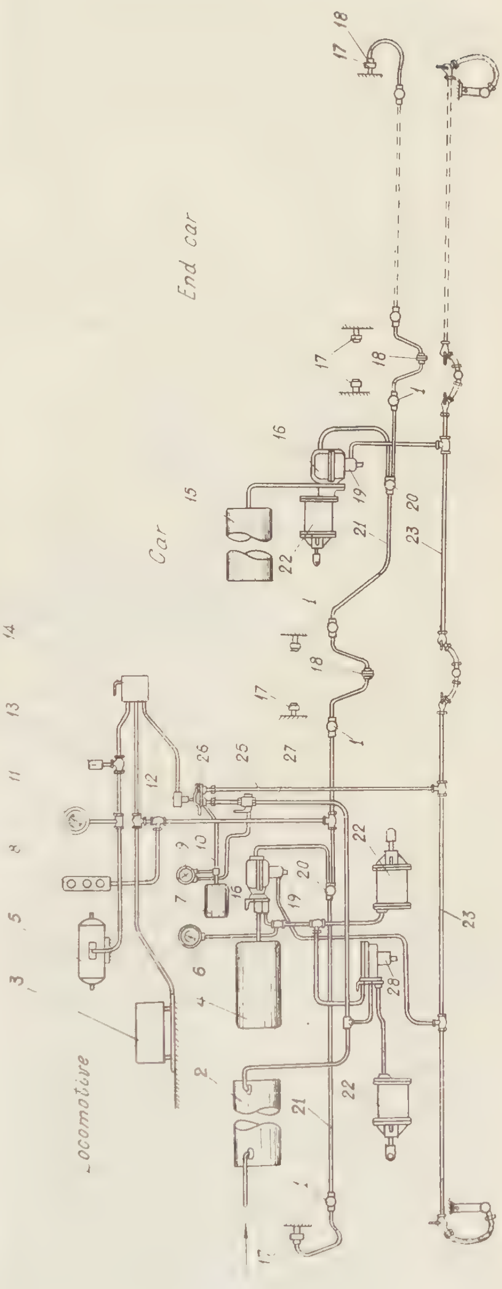


Fig. 6. Schematic diagram of electropneumatic brake for passenger trains.

The following electropneumatic brake equipment is installed on a locomotive (fig. 6): D.C. and A.C. generator 5 with voltmeter 11 and starting device 13, control unit 3, lamp signalling device 8, brake valve 26 with controller 12, main buting valve 16, two electric wires in tube 21, end two-tube terminal boxes 1, middle three-tube terminal box 20, intercar connections 18, end sockets 17, distributing valve 19, auxiliary reservoir 15, brake cylinder 22 and brake pipe 23.

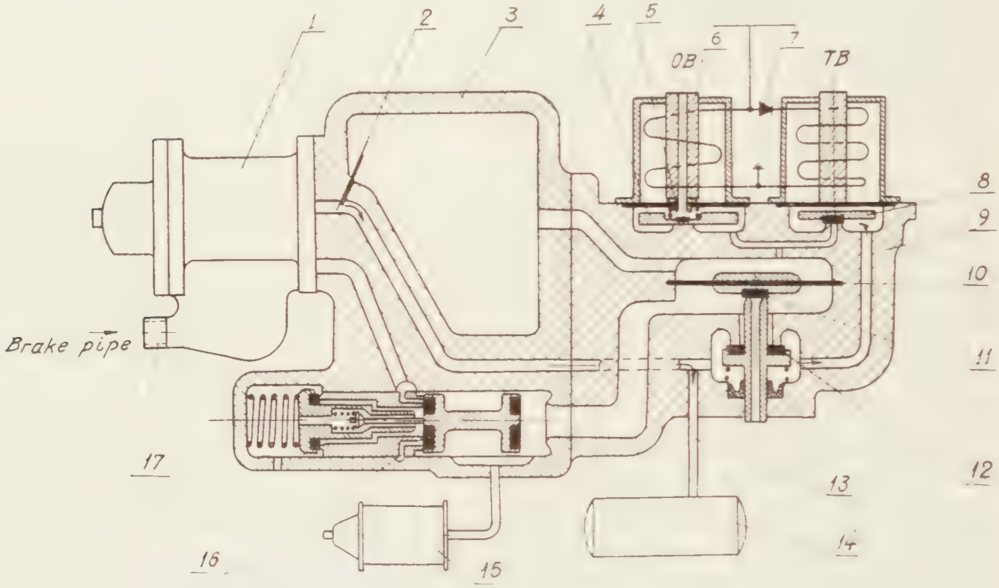


Fig. 7. — Electric air distributor.

switch 14, electric air distributing valve 16, repeating relay 28, two line wires in tube 21, end two-tube terminal boxes 1, middle three-tube terminal box 20, end sockets 17, intercar connections 18 with plug heads.

The pneumatic brake equipment of a locomotive consists of a compressor delivering compressed air into main reservoir 2, brake valve 26, connected by pipe 27 to main reservoir 2, by pipe 25 to brake pipe 23 and by pipe 10 to equalizing reservoir 7, pressure gauge 9 connected to the main and the equalizing reservoirs, distributing valve 19, auxiliary reservoir 4, brake cylinders 22 with pressure gauge 6.

A car is equipped with electric air distri-

All the wires in the locomotives and cars are laid in metal tubes.

The plug heads of intercar connections 18 are secured in end sockets 17 on the last car and on the front buffer beam of the locomotive.

Figure 7 shows a diagram of the electric air distributor. It consists of the following units and parts: distributing valve 1, working chamber 3, armature 4 of release valve OB, valve 5 and core 6 of release valve OB, locking electric valve 7, armature 8 of application valve TB, housing 9, diaphragm 10, exhaust valve 11, feeding valve 12, pipe 13, auxiliary reservoir 14, brake cylinder 15, differential switching valve 16, brake pipe connec-

tion 17. The space above diaphragm 10 is connected by a duct to the space of working chamber 3.

Operation of Electric Air Distributing Valve.

This valve is designed to charge, apply and release the brakes.

Charging the brakes. — The D.C. tension is disconnected from the line. Armature 4 with the valve of release valve OB and armature 8 of application valve TB are in their lower position. Air from the brake pipe through distributing valve 1, duct 2 and pipe 13 fills auxiliary reservoir 14, the same as with pneumatic brakes.

Application of brakes. — A D.C. voltage of direct polarity (plus to the wire, minus to the ground) is fed to the line. The current, upon flowing along the coils of the release OB and application TB valves excites them. Armature 4 is attracted to the seat of valve 5, disconnecting the upper space above diaphragm 10 from the atmosphere. Armature 8 is attracted to the core and permits air to pass from auxiliary reservoir 14 into the space above diaphragm 10.

Diaphragm 10 bends downward and opens valve 12. Air from auxiliary reservoir 4 flows along pipe 13 under valve 12 into the space under diaphragm 10 and shifts the differential valve to the left, pressing it against two concentric protrusions, and then passes into brake cylinder 15. As the pressures on diaphragm 10 become equal it bends upward until valve 12 closes.

For complete application of the brakes the brake valve handle is kept in the application position for 5 sec and more. During this interval the air from the reservoir will have time to flow over into the brake cylinders until the pressure in them is completely equalized.

Lap. — If it is required to apply the brakes in several stages, then after keeping the brake valve handle for a brief time (1 to 2 sec) in the application position the handle is transferred to the lap position. The magnitude of the braking stages depends upon the interval during which the brake valve handle was kept in its application position.

Direct current with a reverse polarity (minus to the wire, plus to the ground) is fed to the line. Application valve TB is not excited, as locking electric valve 7 does not let a current with such a polarity into the coil of application valve TB. Armature 8 drops away and closes with its valve the access of air from auxiliary reservoir 14 to the space above diaphragm 10. Release valve OB remains excited and keeps armature 4 attracted. The upper space above diaphragm 10 remains disconnected from the atmosphere.

If any air leaks out of the brake cylinder it is automatically replenished.

In case of leakage of air, diaphragm 10, under the action of the pressure established above it, bends downward, opens valve 12 and air from auxiliary reservoir 14 will replenish the brake cylinder.

The brake cylinders of all the cars of the train are charged during the same time, regardless of their volume and tightness.

A constant charging time is attained due to the volumes of the working chambers and the diameter of the openings in the application valves of all the devices being identical, therefore the working chambers are charged with air in all the cars of the train practically simultaneously.

The opening of valves 12 is automatically regulated so that the brake cylinders are charged during the same time as is required to charge the working chambers and the space above diaphragm 10. Thus the greater the volume of the brake cylinder, the greater the distance over which feeding valve 12 will be opened when charging brake cylinder 15.

Releasing of brakes. — The feeding of direct current to the line is stopped. Armature 4 under the action of a spring will lower and open the atmosphere openings in the seat of valve 5 and in the core 6 of release valve OB, through which air from the space above diaphragm 10 will be released to the atmosphere.

Diaphragm 10 under the action of the pressure from below will bend upward and

valve 11 will open the orifice, through which air from the brake cylinder is released to the atmosphere.

If the brakes are to be released by stages, then the brake valve handle is transferred from its release to its lap position. When this is done the exhausting of the air to the atmosphere from the space above diaphragm 10 will be stopped.

When the brakes are being released by stages and the brake valve handle is in its lap position release valve OB will be excited and will attract armature 4, which will close with its valve the opening in the seat of valve 5.

Air from the brake cylinder will be released to the atmosphere until the pressure in it will drop to that remaining under diaphragm 10. At this moment diaphragm 10 will move downward, valve 11 will close the orifice and the exhausting of the air from the brake cylinder to the atmosphere will be stopped.

The magnitude of the releasing stage depends upon the time during which the brake valve handle is kept in its release position. To obtain several stages of releasing the brakes the procedure described above is repeated the required number of times. The duration of complete releasing of the brakes is determined by the volume of the working chamber, as well as by the dimensions of the orifice in the nipple of valve 5 and constitutes 3.5 to 4.5 sec.

The duration of releasing, the same as that of application, is practically constant and does not depend upon the volume and the tightness of the brake cylinder.

This is attained due to automatic adjustment by diaphragm 10 of the gap between valve 11 and its seat until the pressure under diaphragm 10 and in the brake cylinder will drop simultaneously with a reduction of the pressure above the diaphragm.

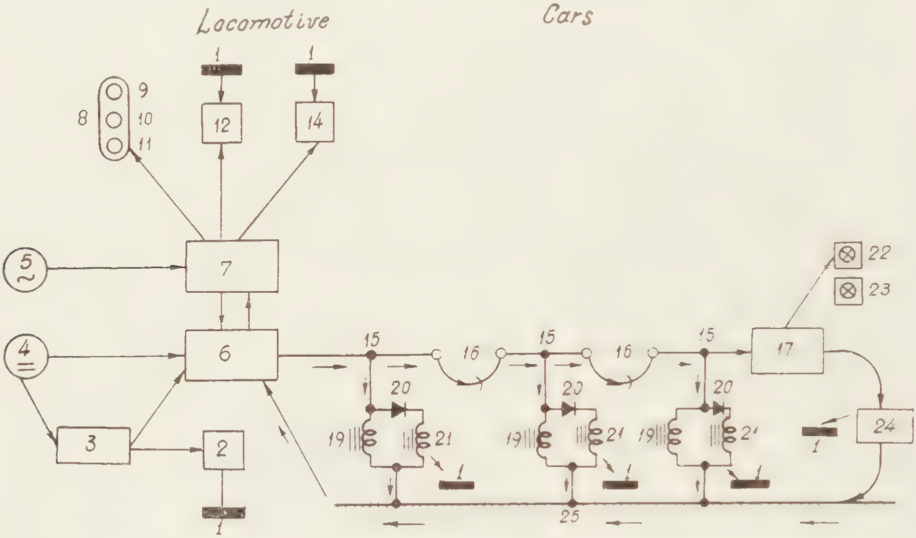


Fig. 8. — Schematic diagram of single-wire electropneumatic brake for goods trains.

b) *Single-wire electropneumatic brake for goods trains.*

A schematic diagram of the single-wire electropneumatic brake is shown in figure 8.

The locomotive is provided with D.C. 4

and A.C. 5 generators, control unit 6 and operating unit 7, brake valve with controller 3, an emergency valve with two windings on coils 12 and 2, lamp signalling device 8 with three lamps 9, 10 and 11,

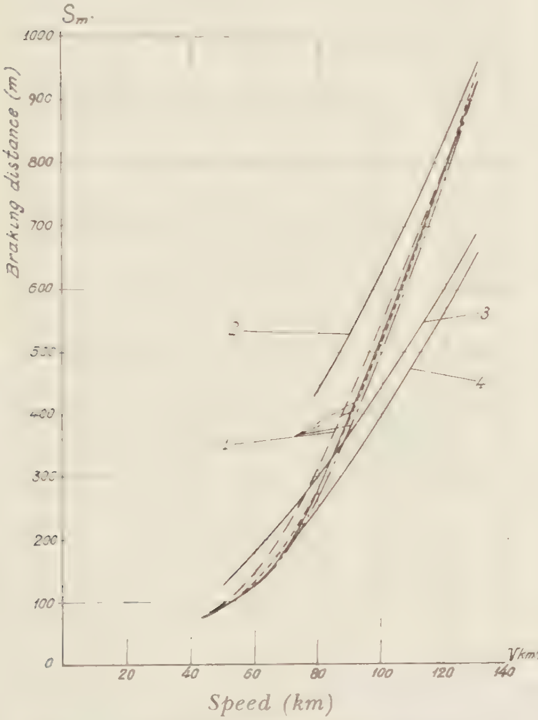


Fig. 9. — Braking distances of an electric train :

1) with automatic duty and cast iron phosphorous brake shoes; empty and loaded, 6, 12 and 17 tons per car;
2) with composition brake shoes, loaded cars, 17 tons each, without automatic duty;
3) with composition brake shoes, empty cars without automatic duty;
4) with composition brake shoes, loaded cars, 17 tons each, with automatic duty.

charging valve 14, electric distributing valve 20 with release 19 and application 21 electromagnetic valves, line wire 15.

The cars are outfitted with electric distributing valves 20, line wire 15, intercar connections 16 and, besides this the last car is provided with terminal unit 17, signal lamps 22 and 23, signalling device 24 showing that the angle cocks are closed. All the devices connected with the brake pipe are designated by the number 1. Rails 25 serve as the second wire of the train circuit.

The condition of the electric line is controlled by means of alternating current from generator 5 with the aid of operating unit 7 and terminal unit 17. Alternating current with a voltage of 30 to 40 V is used for this end.

As a result of the action of terminal unit 17, which is a relay impulse generator, the current in the line circuit is modulated with low-frequency signals. These signals are taken up by locomotive operating unit 7.

When the line is in good order the armature of the relay in unit 7, which has a release delay that is greater than the intervals between the impulses created by terminal unit 17, remains attracted. Through its contacts, when the brake valve handle is in its release position, current is fed to lamp 9 and the winding of coil 2 of the emergency valve, and to the winding of coil 12 when the brake valve handle is in its other positions. If the circuit is disrupted (a short circuit or a torn wire), upon which the impulse action of terminal unit 17 is stopped, the armature and the relay of unit 7 drop away, lamp 9 goes out and the tension is removed from coils 2 or 12, as a result of which the emergency valve operates and emergency application of the air brakes takes place. The same happens when the brakes are applied with the aid of an emergency application valve (emergency stop handle), whereupon as a result of the reduction of pressure in the brake pipe the contacts in the signalling device closing cocks 24 break the circuit between line wire 15 and rails 25.

Upon application of the brakes a direct current with a voltage of 150 V with a definite polarity (plus to the wire and minus to the rails) is fed to the line circuit through control unit 6, while in the lap position the polarity of the current in the circuit is changed (minus to the wire, plus to the rails). The action of the brake equipment during application and in the lap position is the same as in the electro-pneumatic brake according to the two-wire

diagram for passenger trains with the only difference, that during application and in the lap position charging valve 14 is excited and the brake pipe is charged with compressed air, the pressure in it being increased up to 6.3 to 6.5 atm. Due to this the inexhaustibility of the brake action is considerably increased.

of railway rolling stock can be expressed as follows :

$$\Sigma K \varphi_K = Q \psi_K$$

where :

K is the total force acting on the shoes;
φ_K is the brake shoe coefficient of friction;
Q is the load on the wheels;

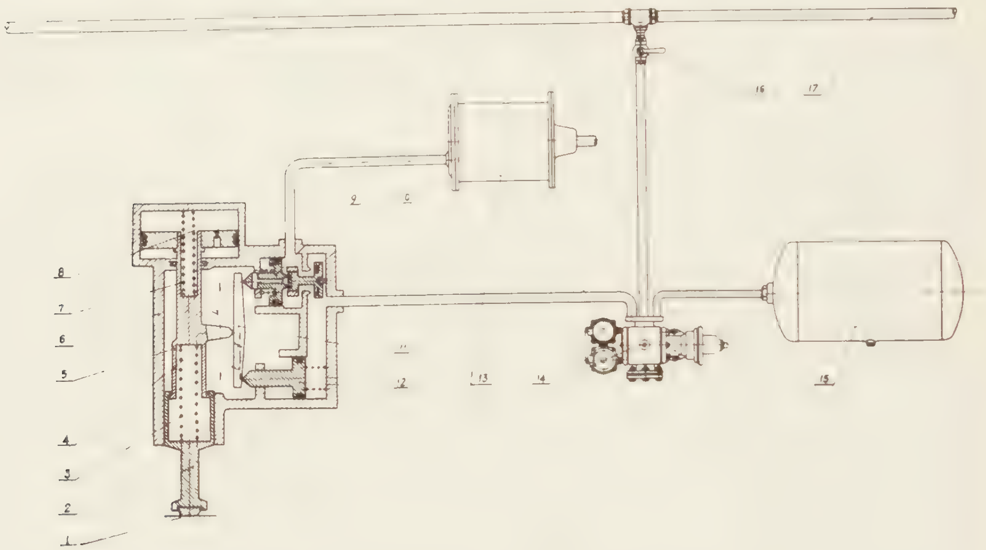


Fig. 10. — Diagram of load automatic duty.

1) plate; 2) plunger); 3) and 7) springs; 4) stop; 5) damper piston; 6) body; 8) orifice; 9) and 12) pistons; 10) valve; 11) lever; 13) brake cylinder; 14) air distributor; 15) auxiliary reservoir; 16) cut-off cock; 17) brake pipe.

Instead of the existing kerosene lamps, electric signal lamps 22 and 23 are installed on the last car, the lamps being supplied with current from the electropneumatic brake circuit through terminal unit 17. Thus simultaneously with the introduction of electropneumatic brakes on goods trains the problem of improving the illumination of the rear end signal lamps is solved.

Freight train automatic load compensating brake.

The basic condition for efficient braking

ψ_K is the coefficient of adhesion of the wheels with the rails.

The braking force of a pair of wheels $\Sigma K \varphi_K$ should approximate the force of adhesion of the wheels with the rails $Q \psi_K$.

With a given value of φ_K the braking force becomes a function of the weight Q. From this it follows that the optimum brake duty should be ensured by a constant specific braking force over the whole carload range.

The load brake duties that are being used at present are far from complying with this condition. They are characterized by

sharp fluctuations in the braking force at various degrees of loading the car, which are accompanied by a loss of efficiency or a danger of slipping of the wheels. Besides this change over of the duty by hand leads to instances of improper setting of the brakes and requires great attention on the part of the servicing staff.

A constant specific braking force for various loading of a car can be ensured automatically by means of a device called a freight train automatic load compensating brake. Its use solves several practical problems, viz., makes it possible to considerably increase the braking force of cars, improves the control of the brakes, reduces the longitudinal dynamic forces acting during application, reduces instances of wheel slipping, replaces manual changing of brake duty with automatic control.

The employment of automatic brake power control on goods cars permits running trains at a speed of 100 km/h down a 1 ‰ (1 in 1 000) grade, it being possible to come to a stop over a distance of up to 1 000 m. The employment of automatic control on electric trains considerably reduces the braking distance (fig. 9).

The design and action of the automatic load compensating brake consists in the following (fig. 10). On the frame of the car body there is located housing 6 of the control unit, while the side members of the bogie carry supporting plate 1, which is in contact with plunger 2. The braking duty is established by means of damper piston 5 depending upon the statical deflection of the springs, which depends in turn upon the load in the car.

When the car is empty piston 5 under the action of spring 7 occupies the lowest position in the cylinder. Loading of the car causes the piston to rise under the action of spring 3. As stop 4 is connected with the piston, movement of the latter changes the ratio of the arms of lever 11. This change of the arms by means of an air relay creates a pressure of the air in brake cylinder 13 that is in proportion to the weight of the car. During application the air flows from distributing valve 14 into the brake cylinder until the system of pistons 9, 12 and lever 11 is equalized, when valve 10 will close.

The dynamic oscillations of the car body and bogies that arise in motion have practically no influence on the proper setting of the brake duty. This is explained by the fact that during the action of springs 3 and 7 on piston 5 the air does not have

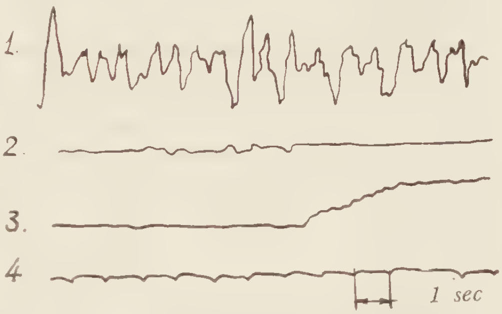


Fig. 11. — Oscillogram of the dynamic fluctuations of the air pressure in a brake cylinder with time at a car speed of 80 km/h.

1) fluctuations of car body;
2) fluctuations of piston 5 (fig. 10);
3) pressure in brake cylinder;
4) time marks.

time to flow from one space of the cylinder to the other one through orifice 8. In this instance an insignificant movement of the piston (fig. 11) is sufficient to make the compression and rarefication created thereupon in the cylinders counteract the force of one or the other of the springs.

The automatic load compensating brake for electric trains differs only in the diagram of the air relay.

At present the automatic load compensating brake equipment is being tested in operation and has been prepared for mass production for installation on goods vehicles and electric trains.

The problem of longitudinal dynamic forces when applying brakes to long goods trains.

With an increase in the length and weight of goods trains the longitudinal dynamic forces in the intercar connections

grow as a result of a certain non-uniformity in the action of the brakes when the brake cylinders are being filled. The longitudinal forces in a train also depend upon the presence of gaps in the couplers of the cars and in trains weighing from 6 000 to 8 000 tons consisting of from 75 to 100 bogie cars they can be very considerable and cause damage to the rolling stock.

In this connection during recent years on a number of railways the problem has arisen of developing various engineering solutions to improve the smoothness of brake application in long trains, and therefore the necessity of experimental investigation of the longitudinal stresses in trains upon application of the brakes. Let us consider, for example, some results of investigations carried out on the railways of the U.S.S.R.

In 1960, the All-Union Scientific Research Railway Transport Institute together with the Dniepropetrovsk Institute of Railway Engineers carried out comparative test of cast iron and composition brake shoes in a train weighing 7 000 tons on an experimental circular track.

The test train was made up of 84 loaded bogie cars with hand brake platforms, two laboratory cars and one bogie van containing a power plant (fig. 12). The length of the train was 1 000 m. All the cars were equipped with distributing valves, conditional No. 270-002 and brake slack adjusters. The rods protruded from 95 to 115 mm. When preparing the train for the tests the free gaps in the automatic couplers between all the cars were measured. The average gap per one intercar connection constituted 43 mm. A type ВЛ-23М electric locomotive and a type ТЭ-3 diesel locomotive, equipped with a brake valve, conditional No. 222 and type МТ 3-135 air distributors, were employed for hauling the train.

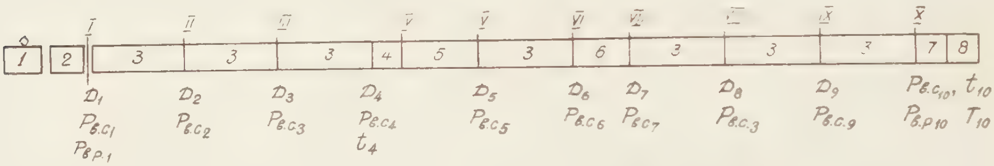


Fig. 12. — Layout of the test train set, weight 7 000 tons.

1) electric locomotive type ВЛ-23;
2) the diesel locomotive type ТЭ-3;
3) ten gondola cars;
4) laboratory car;
5) nine gondola cars;
6) five gondola cars;
7) laboratory car;
8) van with power plant.

I-X - places of location of measuring devices (sections of train).
1) Δ_1 — Δ_3 — dynamometric automatic couplers;
2) Pu_1 — Pu_{10} — pressure gauges — transmitters for measuring the pressures in the brake cylinders;
3) P_{M_1} — $P_{M_{10}}$ — pressure gauges — transmitters for measuring the pressures in the brake pipe;
4) T_{10} — brake type relay;
5) t_4 and t_{10} — time recorders.

The longitudinal stresses appearing upon application of the brakes were measured at nine sections, strengthened automatic couplers equipped with wire transmitters being used as dynamometers. These couplers differed from the standard ones in having thickened shank walls and were manufactured of special grade ГЛ-27 heat-treated steel, which ensured the recording of stresses up to 300 tons without any yielding of the steel being noted.

Recesses 80 × 50 mm in size and 3 mm deep were milled in all the surfaces of the coupler shanks to contain the transmitters and protect them against mechanical damage. The working transmitters with a resistance of 200 ohms and a base of 20 mm were glued in these recesses along the coupler axis. At right angles to these transmitters similar ones were glued on to compensate for the influence of changes in temperature. To exclude the influence of any possible bends of the couplers the

working transmitters of opposing surfaces were connected in parallel to one of the arms of the measuring half-bridge. The working transmitters of adjacent surfaces were connected to this arm in series. The compensating transmitters were connected in the same way to the second arm of the half-bridge (fig. 13). Due to such a series-parallel connection of the transmitters the the calibrated tensile force up to 300 tons the couplers showed a linear relationship and after the load was removed the readings of the amplifier returned to zero. As a result of this calibration the characteristics of the shunt required for ensuring the proper scale when recording the longitudinal stresses in a train when transferring to a multi-channel dynamic amplifier were de-

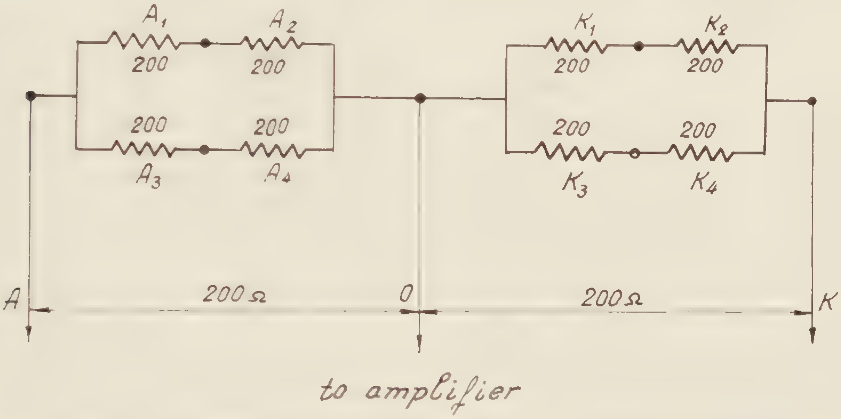


Fig. 13. — Diagram showing how transmitters of measuring half-bridge of automatic couplers — dynamometers were connected.
A_1, A_2, A_3 and A_4 — active transmitters;
K_1, K_2, K_3 and K_4 — compensating transmitters.

arms of the measuring half-bridge had a resistance of 200 ohms.

The recesses in the side surfaces of the coupler shank containing the transmitters were filled with a plastic material for insulation. The wires from the transmitter terminals were passed through drilled holes into the coupler and were connected to a panel located on the strengthening ribs of the large tooth of the coupler head. The terminal panel made of textolite, to which the screened wires to the coupler transmitters were connected, together with a rubber gasket was secured to the coupler body. This panel was closed with a metal lid to prevent any moisture or foreign particles penetrating inside.

The automatic couplers equipped in this manner were calibrated on a press before the tests with the aid of a single-channel static amplifier. Along the whole range of termined — a resistance of 100 ohms corresponded to a force for various couplers of 200 to 220 tons.

The automatic couplers — dynamometers were installed on a car at those sections in the train where it was required to measure the longitudinal stresses (fig. 12).

Both arms of the half-bridge of each coupler-dynamometer were connected by a screened wire to the channel of the amplifier, in which there was installed a second half-bridge consisting of similar wire transmitters, and thence were connected to the loop of an oscillograph.

For recording the pressure of the air in the brake pipe and cylinders on oscillographs rheochord manometric transmitters were used, the signals from which were directly fed to the oscillograph loop without amplification.

The measuring apparatus was supplied

with current from a power plant located in a special van.

In the laboratory car located the thirty-first from the head of the train there were recorded on a type 0C-60 oscillograph the longitudinal stresses and the changes in the brake cylinder pressure for the six test sections in the head part of the train, the pressure of the air in the brake pipe of the first car, with the time being recorded every second.

In the laboratory car located at the rear of the train in front of the power-plant van there were recorded on a type CP-5 oscillograph the longitudinal stresses and the brake cylinder pressure for sections VII, VIII and IX, the pressure of the air in the brake pipe and brake cylinder of the eighty-fifth car, the kind of brakes and the time. Besides the oscillograph records the work of the air distributors of cars 85 and 86 was recorded with the aid of an indicator apparatus. During the tests the initial speed of application and the braking distance were recorded.

The iron brake shoes were tested with all the brakes regulated to load duty, while for the composition shoes the air distributors were regulated to their empty and intermediate duties, the pressure of the composition shoes being 3.0 tons per axle for empty duty and 5.4 tons for intermediate duty, which approximately corresponded to the calculated ratings for adhesion *(Table 1)*.

During each cycle of tests complete service and emergency applications were carried out from the locomotive and applications by opening the emergency stop handle on the last car were carried out from speeds of 80, 70, 50, 30 and 10 km/h.

Figure 14 shows an oscillogram for emergency application of the brakes from a speed of 70 km/h. Before beginning this test the controller was switched off and the train brakes were simultaneously actuated. At the beginning of application the train was stretched out and the gaps in the couplers were open. As a result, as can be seen from the oscillogram, during application the cars ran into each other at certain speeds and a number of shocks resulted that passed along the train.

An analysis of the application oscillograms shows that the nature of the longitudinal stresses with composition brake shoes is the same as with cast iron shoes, viz., during application of the brakes from the locomotive compressing stresses are created in the train, while when the emergency stop handle at the rear of the train is used tensile stresses are created. The distribution

TABLE 1.

Type of brake shoe	Pressure in brake cylinder in atm. at speed km/h, of :		Actual force on brake shoe in tons at speed km/h, of :		Friction coefficient of brake shoes at speed km/h, of :			Specific brake force in kg/ton at speed km/h, of :		
	10	40-80	10	40-80	10	40	80	10	40	80
Cast iron brake shoes, load duty	3.0	4.0	3.0	4.0	0.191	0.110	0.085	56	43	33
Composition shoes, empty duty	1.3	1.5	1.3	1.5	0.350	0.300	0.270	45	43	39
Composition shoes, intermediate duty	1.5	2.7	1.5	2.7	0.342	0.268	0.240	50	70	64

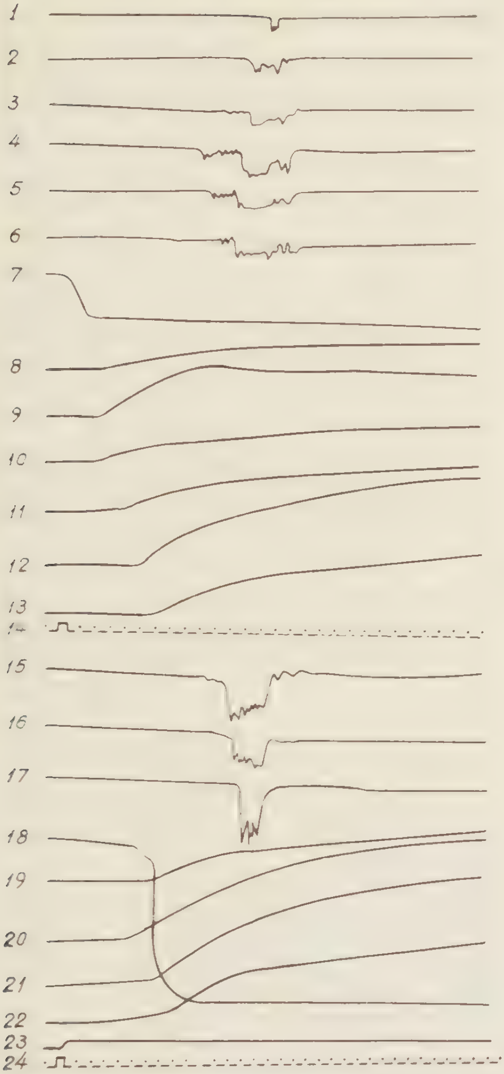


Fig. 14. — Oscillogram of emergency brake application at speed of 70 km/h.

1) longitudinal stress between diesel locomotive and first car (section I);
2) stress between 10th and 11th cars (section II);
3) stress between 20th and 21st cars (section III);
4) stress between 31st and 32nd cars (section IV);
5) stress between 40th and 41st cars (section V);
6) stress between 50th and 51st cars (section VI);
7) pressure drop in brake pipe of first car;
8) charging of brake cylinder of first car;
9) charging of brake cylinder of 11th car;
10) charging of brake cylinder of 21st car;
11) charging of brake cylinder of 30th car;
12) charging of brake cylinder of 41st car;
13) charging of brake cylinder of 51st car;
14) recording of time every second in laboratory car;
15) longitudinal stress between 55th and 56th cars (section VII);
16) stress between 65th and 66th cars (section VIII);
17) stress between 75th and 76th cars (section IX);
18) pressure drop in brake pipe of 85th car;
19) charging of brake cylinder of 56th car;
20) charging of brake cylinder of 66th car;
21) charging of brake cylinder of 76th car;
22) charging of brake cylinder of 85th car;
23) brake mark;
24) recording of time every second in laboratory car.

of the longitudinal stresses along the length of the train also remained unchanged (fig. 15). In both instances the places where the maximum stresses are observed are sections VII and VIII, i.e. the last third of the train.

As regards the magnitude of the stresses, decoding of the oscillograms showed that in a train with composite brake shoes when empty brake duty is employed they are less than for load duty with iron shoes *(Table 2)*. The maximum values of the longitudinal stresses in the first instance equalled 130 tons, in the second instance 160 tons. At a speed of 80 km/h the stresses in both instances equalled 100 tons. When the distributing valves were regulated to intermediate duty the longitudinal stresses for composite shoes increased somewhat — at low speeds it equalled 135 to 145 tons and at speeds of 70 to 80 km/h — 100 to 110 tons.

Figure 16 contains graphs of the maximum longitudinal stresses depending upon the initial speed at which the brakes were applied for various types of brake shoes, which show the special features of application of brakes when using composite brake shoes. When regulated for empty duty, while having the same efficiency as iron brake shoes, the composite shoes at all the speed ranges from 10 to 80 km/h ensure a higher smoothness of application, while when regulated for intermediate duty the composite brake shoes have a greater efficiency than their iron counterparts, and smoother application is ensured in the range of low speeds from 10 to 40 km/h, which is explained by a more uniform change in the specific braking force with a reduction in speed and by lower braking

TABLE 2.

Type of brake shoes and brake duty	Speed, km/h	Average (numerator) and maximum (denominator) compression stresses in tons by section of train								
Cast iron brake shoes, load duty	80	50/55	60/70	65/75	70/80	75/85	80/90	90/100	75/80	60/75
	70	50/55	60/75	70/80	75/85	80/90	85/100	90/105	80/90	60/80
	50	55/60	65/80	75/85	85/90	90/100	95/110	100/115	90/100	65/85
	30	60/65	70/85	80/90	90/100	100/110	110/120	115/135	110/120	70/90
	10	60/70	70/90	90/100	100/120	110/140	125/150	140/160	120/140	80/100
Composition shoes, empty duty	80	30/40	35/50	40/60	60/70	70/80	85/90	90/100	80/85	60/65
	70	30/40	35/50	45/60	60/70	70/80	85/90	90/105	85/90	65/70
	50	35/40	40/50	50/60	60/70	70/80	90/100	95/110	90/95	75/80
	30	35/40	45/50	55/60	65/70	80/90	105/120	108/110	95/100	80/85
	10	40/50	50/60	60/70	70/80	90/100	115/130	110/120	100/110	90/100
Composition shoes, intermediate duty	80	30/45	40/55	50/65	60/70	70/75	80/90	95/105	90/100	65/75
	70	30/50	40/60	50/70	65/75	75/80	90/100	95/110	95/105	70/85
	50	35/50	45/60	60/75	75/80	85/90	100/110	105/120	100/115	80/90
	30	40/50	50/60	65/75	80/90	90/110	110/130	110/125	110/125	85/95
	10	40/50	50/60	70/75	85/90	100/110	120/145	120/130	120/130	95/100

forces of the composite shoes at low initial speeds of application.

In this connection when composite shoes are employed the general level of the longitudinal stresses is lowered, as the stresses at low speeds, which are the maximum ones, are the ones used in calculation of the strength of cars. Besides this a reduction in the longitudinal stresses at low speeds is also important when taking into account that under operating conditions most of the complete applications of brakes take place at low speeds when stopping at stations or signals.

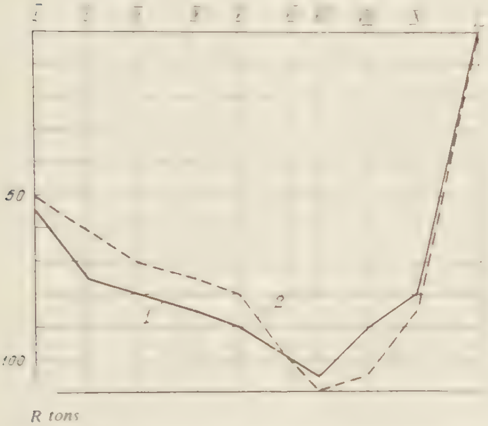


Fig. 15. — Graph showing distribution of longitudinal stresses along length of train upon emergency application of brakes.

1) iron brake shoes;
2) composite brake shoes.

It should be noted that a certain reduction of the specific braking force in the low speed range, which has a favourable influence on the longitudinal dynamics of a train, does not have any noticeable negative influence on the total length of the braking distance as a result of the considerable reduction of the braking distances in the high speed range.

Figure 17 shows graphs of the relationship between the braking distance and the speed for various types of brake shoes. When composite shoes are regulated to empty duty and iron shoes to load duty the braking distances are practically the same. When the composite shoes are set to intermediate duty the braking distances at speeds of 70 to 80 km/h were reduced by 15 to 20 %, this reduction being greater with a further increase in speed.

Therefore composite brake shoes of the type 6 KB-10 material, which have a high braking efficiency, do not cause any noticeable increase in the longitudinal stresses in long trains. When applying the brakes at high initial speeds the stresses do not exceed the tolerated values, while for low initial speeds the level of the stresses is lower than in trains with iron brake shoes. Thus it was ascertained that in respect to the requirements regarding the tolerated level of longitudinal dynamic stresses the composite brake shoes are also quite satisfactory for goods trains weighing about 7 000 tons. In the future composite brake shoes combined with electropneumatic con-

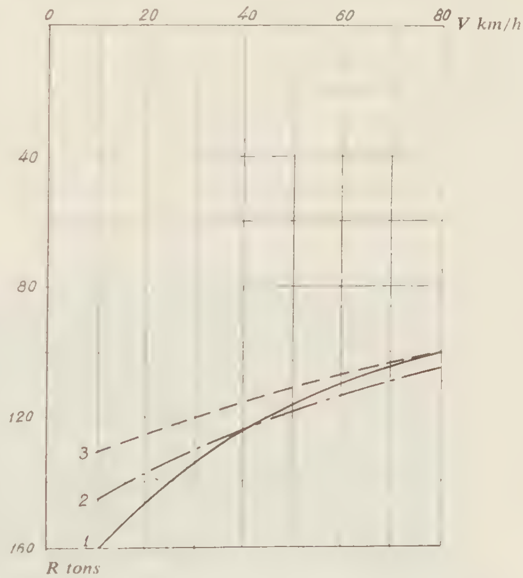


Fig. 16. — Relationship of maximum longitudinal stresses to speed for various types of brake shoes.

1) cast iron shoes (pressure 34 %);
2) composition shoes (pressure 26 %);
3) composition shoes (pressure 15 %).

trol of goods train brakes may be used as a powerful means of increasing the braking efficiency of goods rolling stock without

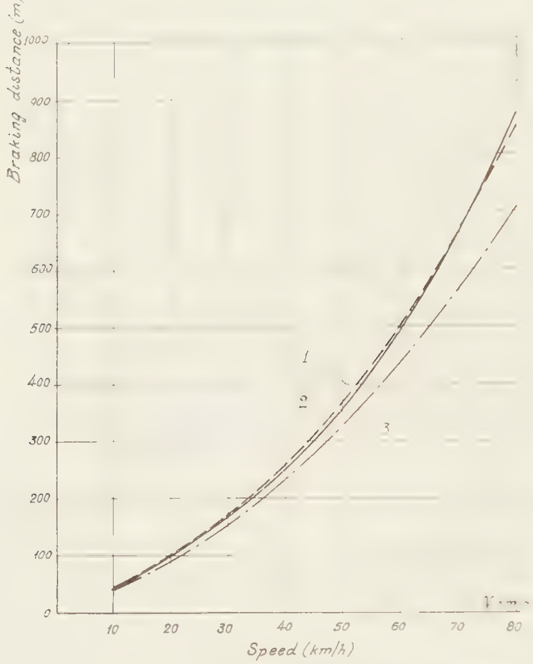


Fig. 17. — Relationship of braking distance to speed for various types of brake shoes for 7 000 ton train.

1) cast iron shoes with pressure coefficient of 34 %;
2) composition shoes with pressure coefficient of 15 %;
3) composition shoes with pressure coefficient of 26 %.

any limits in respect to the maximum speed and the length of trains.

When similar tests were carried out with electropneumatic control of the automatic brakes it was found that the level of the maximum longitudinal dynamic stresses was reduced several times and did not exceed 50 to 60 tons under the most unfavourable conditions of applying the brakes in a goods train weighing 7 500 to 8 000 tons.

There are also certain reserves for reducing the level of the longitudinal dynamic stresses when applying the brakes as a result of selecting the optimal indicator diagram of the brake cylinder refilling indicator diagram when pneumatic brake control is used. To a certain degree this problem is solved by means of the three-stage diagram used in the AB type of distributing valve being employed on the U.S.A. railways and in the air distributor cond. No. 135 being employed on the U.S.S.R. railways (fig. 18).

Recently on the railways of the U.S.S.R. air distributors, given the conditional number 270-002, have begun to be employed in goods vehicles. The brake cylinder refilling indicator diagrams during emergency application of the brakes for the first and the hundredth car of a goods train are shown in figure 19.

When applying the brakes to long goods trains equipped with the distributing valves of conditional No. 270-002 the magnitude of the longitudinal dynamic stresses is noticeably reduced.

The results of investigating the adhesion of the wheels to the rails during application of the brakes.

As is well-known, the force of adhesion of the wheels to the rails is a factor limiting the maximum braking force of railway rolling stock. On one hand when designing and operating brake systems it is necessary

Fig. 18. — Diagram of emergency application of brakes in train 1 200 m long with air distributors, cond. W 135.

1) pressure of air in brake pipe of first car;
2) pressure of air in brake pipe of last car;
3) pressure of air in brake cylinder of first car;
4) pressure of air in brake cylinder of last car.

to comply without fail with the condition that the braking force should not be greater than the possible force of adhesion of the wheels to the rails to avoid wedging of

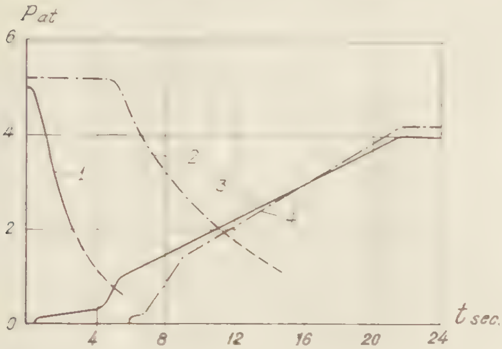


Fig. 19. — Diagram of emergency application of brakes with two-stage refilling of brake cylinder (with air distributors, cond. W 270-002).

1) pressure of air in brake pipe of first car;
2) pressure of air in brake pipe of last car;
3) pressure of air in brake cylinder of first car;
4) pressure of air in brake cylinder of last car.

the wheels upon application of the brakes and all the harmful results connected with this. On the other hand with an increase in the speed of trains the braking force of a train must be increased as much as possible, using to the utmost the force of adhesion of the wheels to the rails.

In the practice of the absolute majority of railways the force of the adhesion of the wheels to the rails that may be utilized is estimated by the magnitude of the so-called coefficient of adhesion of the wheels to the rails. From an analysis of the materials received from the various railway administrations, it can be seen that the rated values of this coefficient of adhesion used by the various railways greatly differ from each other. Besides this on a number of railways no strict difference is made between the values of the coefficient of adhesion when hauling trains and when applying the brakes. In fact there should be various rated values of the coefficient of adhesion for traction and for brake application duties.

To define more precisely the values of the coefficient of adhesion of the wheels to the rails that can be realized when applying the brakes the U.S.S.R. railways during the last few years have carried out a great number of experiments with various rolling stock and under various conditions of the surface of the rails in winter and summer operating conditions. These tests were performed in a train consisting of a goods wagon (gondola) or a passenger all-steel car and a car for testing automatic brakes. The coefficient of adhesion was determined on the basis of data obtained when the test train was uncoupled from

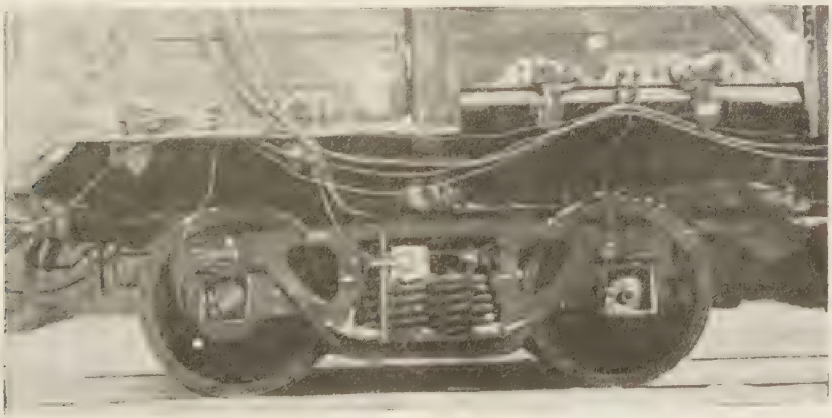


Fig. 20. — Location of deflection gauge and wheel speed transmitter on car.

the locomotive at various initial speeds from V = 120 to V = 10 km/h. The brakes of the goods or passenger car were applied from the brake testing car with the aid of a triple valve directly connecting the brake cylinder of the car being tested to the compressed air reservoirs. The pressure on the brake shoes was selected in such a way as to call forth seizing of the wheels. The moment of sliding was fixed on the film of an oscillograph with the aid of electric apparatus and special devices mounted in the axle boxes of all the experimental cars (fig. 20). Figure 21 shows an oscillogram of the movement of the car wheels during the tests. On this oscillogram it can be seen how the third wheel set of a bogie car during application of the brakes normally revolved, while the fourth set changed its speed, began to slide and then, when the brakes were released, again began to revolve. For complex appraisal of the loading and unloading of the wheels when the brakes were applied the front and rear bogies of the gondola car were equipped with deflection gauges, which recorded on the film of the oscillograph the changes in the deflections of the spring sets at various speeds and loads of the car.

A diagram of the deflection gauge of a bogie spring set is shown in figure 22.

According to the readings of the deflection gauge the deflection of the spring set f (mm) is determined, while if its rigidity « R » (kg per mm) is known it is easy to determine the unloading or overloading of the set of wheels during application of the brakes according to the formula $\Delta Q = f \times R$ (kg).

The value of the coefficient of adhesion was determined according to the known value of the brake shoe coefficient of friction at the moment when the wheels of the gondola car became wedging. After this the critical maximum value of the coefficient of adhesion of the wheels to the rails during application of the brakes was determined according to the formula :

$$\psi_K = \frac{\Sigma K \varphi_K}{Q \pm \Delta Q}$$

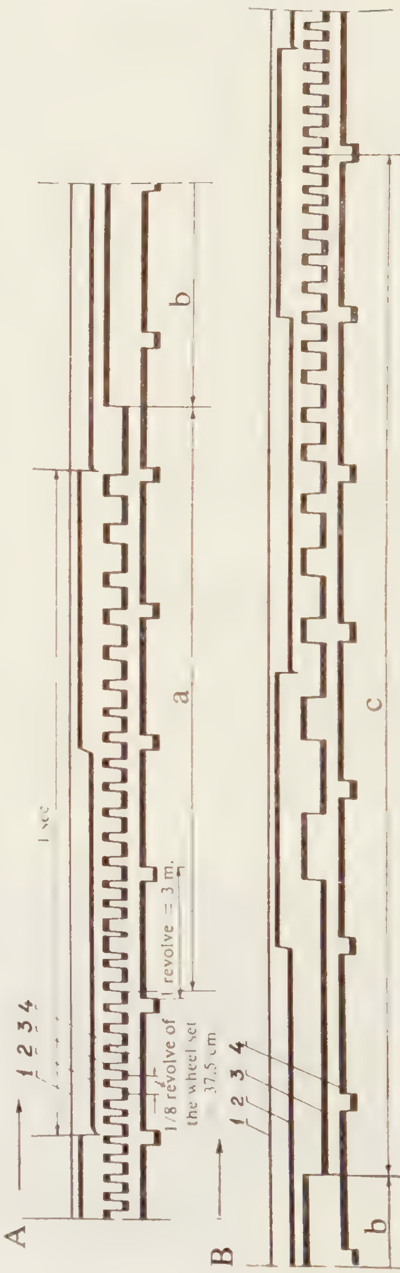


Fig. 21. — Oscillogram of motion of gondola car with rolling of the third and rolling and sliding of the fourth set of wheels.

A. Process wedging of 4th set of wheels.
a) transition from rolling motion to sliding, duration 0.9 sec;
b) sliding;

B. Process of unwedging of 4th set of wheels.
c) transition from sliding to rotary motion, duration 1.85 sec.

1) zero line;
2) recording of time;
3) recording of motion of 4th set of wheels;
4) recording of motion of 3rd set of wheels.

The speed of the gondola car before wedging of the 4th set of wheels — V = 54 km/h after wedging — V = 43 km/h (during application of brakes)

where :

ΣK is the critical sum of the brake shoe pressures on a set of wheels in tons, at which sliding begins;

φ_K is the coefficient of friction of the shoes at the moment when the wheels become wedged;

ployed. At low speeds up to 40 km/h ψ_K is taken equal to 0.14.

The results of tests for determining the coefficients of adhesion of the wheels to the rails during application of the brakes under various operating conditions have shown that the value of ψ_K depends in

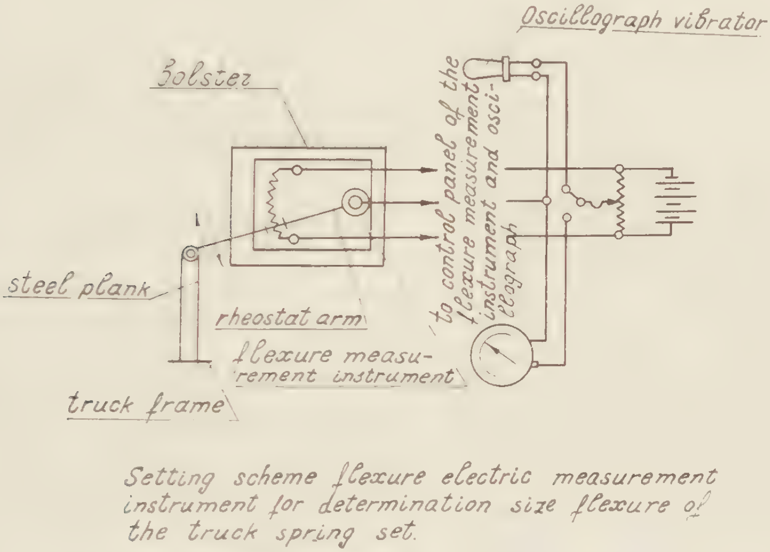


Fig. 22. — Diagram of installation of electric measuring instruments for determining dimensions.

Q is the weight of the load and the car in tons per set (pair) of wheels;

ΔQ is the unloading or overloading of the set of wheels as the result of the action of the brake, in tons.

On the basis of these tests, values of the coefficient of adhesion of the wheels to the rails upon application of the brakes ranging from $\psi_K = 0.09$ to 0.10 were recommended on the railways of the U.S.S.R. for calculations. When determining the braking efficiency of cars with a load per axle exceeding 10 tons the value of $\psi_K = 0.09$ should be used, while for cars with a load per axle up to 10 tons the value of $\psi_K = 0.10$ should be employed.

the main upon the condition of the surface of the rails, the load of the wheels on the rails, the speed, the material of which the brake shoes are made, the duration of contact of the wheels with the rails and the wear of the wheels.

Electric braking.

As can be seen from an analysis of the communications received from the various railway administrations, during the last few years certain attention has been paid to the use of electric braking of locomotives and multiple-unit trains.

Electric braking is accomplished by reverse excitation of the locomotive or motor car traction motors.

Three varieties of electric braking are employed :

1) rheostat (on diesel-electric locomotives);

2) recuperative (on electric locomotives);

3) recuperative rheostat (on multiple-unit trains).

In all instances electric braking is additional to the main friction brake that ensures safe running and serves to regulate the speed of the train. As experience obtained in operation has shown, the use of electric braking of trains leads to considerable economy as the result of reduced wear of the brake shoes, on one hand, and by permitting to increase the average speed of trains on long inclines on the other hand. In the latter instance the considerable change of the speed from its maximum tolerated value to the minimum one, determined by the conditions for releasing and charging the brakes, is absent. Electric recuperative braking, besides the economy indicated above, leads to additional economy which is the result of returning to the contact system the power generated by the traction motors when braking.

During recent years there have begun to appear combinations of rheostat and recuperative electric braking. This way of braking, for instance, is employed on certain types of multiple-unit trains on the U.S.S.R. railways. In this instance the train is braked with recuperation of the power at speeds from 130 to 50 km/h. At speeds below 50 km/h the brake is automatically switched over to rheostat braking, while before the train stops, at a speed of about 7 to 10 km/h, the friction brake with electropneumatic control is switched on. As practical experience obtained on a number of railways has shown, the employment of electric braking on locomotives and multiple-unit trains is a very profitable undertaking.

Even rheostat electric braking, as calculations and the practical experience of a number of railways have shown, is an economically profitable undertaking and is already widely used on diesel-electric locomotives (U.S.A.), A.C. electric locomotives (Japan), etc. As the results of calculations and experiments on the U.S.S.R. railways have shown, the optimum power of the

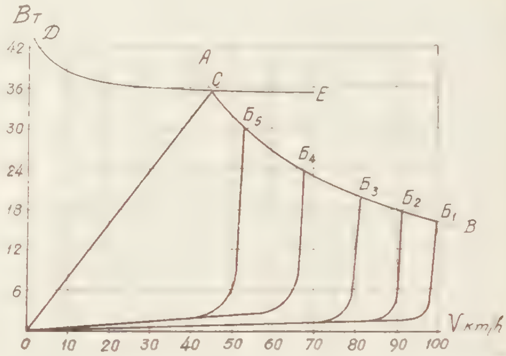


Fig. 23. — Characteristics when employing rheostat brakes.

brake rheostat should be approximately equal to the one-hour power rating of the given locomotive. For example, for the type H 60 A.C. electric locomotive the required power of the rheostat braking is determined as equal to 4 000 kW, which requires a weight of the brake resistances of about 2 000 kg.

For this type of A.C. electric locomotive there have been worked out optimum characteristics of rheostat brake use for various ways of braking (fig. 23).

In figure 23 curve AБ characterizes the limiting of the braking force by the power of the brake resistance, curve OC — by the heating of the main poles of the traction motors, and curve DE — by the adhesion of the wheels to the rails.

For braking to a full stop one characteristic CD, is provided with complete use of the brake resistance power. In this specific instance the limit depending upon adhesion is higher than the maximum braking force.

During speed regulating braking on an down grade the braking force changes along one of the lines OБ, which fill without interruption the whole field of possible

speeds on the down grade for the given electric locomotive.

The driver sets the speed desired and the system ensures intensive increasing of the braking force when this speed is reached. If the down grade is too great and the braking force for maintaining the required speed down it should be greater than that possible according to limiting Aб, then the system is automatically switched over the Aб with simultaneous switching on of the friction brakes of the whole train. Upon restoration (with the practically possible tolerances depending upon the type of train brakes) the system is again returned to the characteristic Oб.

The problem of automation of brake system control.

During the last few years on separate railways there are being carried out experimental investigations of automatic train control with the aid of special apparatus, without any driver.

Thus, for example, information is contained in the magazine « Railway Age » for October 17th, 1960, on the results of tests of an automatic train on the New York subway.

Such a train consisting of three cars was tested for several months on a section of the subway 823 m long.

The movement of the train, which runs between two stations, is controlled by means of alternating current with a frequency of 100 cps, which is coded in various ways on various sections of the track, when there is a train at the first station, the equipment of the second station sends through the rails a current with code 270 (270 impulses per min with the frequency being 100 cps). Upon receiving the code the receiving device of the head car switches on the devices that start the train. Having attained a speed of 47 km/h the train continues to proceed at this speed.

At a certain distance from the second station the train passes over an insulated section of track. Here it receives code 180, after which it slows down to 5 m.p.h. Then the train passes over the next insulated section, where it receives the code 0 and stops within a distance of 1.5 m from the predetermined point. After the train has stopped a current with the code 75 is fed to the wire loop lying between the rails and the doors of the cars open. The head signals change to tail ones, and vice versa. The name of the point of destination also changes. Then an automatic dispatcher device at the second station actuates the apparatus, which after one minute from the moment of opening the doors switches off code 75, as a result of which the doors will close and the brakes will be disengaged. The equipment located at the first station sends a current with the code 270 along the rails, which is picked up by the receivers mounted on the first car (previously it was the last one). The train is accelerated up to a speed of 47 km/h, at which it returns to the first station.

All the equipment is provided with safety devices. If any unforeseen incidents occur when the train is in motion, for instance a too great increase in the speed, a compensating device will reduce it to the normal value. If the regulating device fails the train will be deprived of current and will stop. In case of a faulty track, brakes, etc., the train will remain at the station.

On the U.S.S.R. railways there are being tested devices for the automatic control of multiple-unit trains consisting of ten cars on surface railways. In this instance a special device in the form of a calculating and analyzing machine controls the movement of the train according to a predetermined schedule with planned stops.

For such trains, especially with frequent stops at precisely predetermined spots, the brake system must comply with more strict requirements.

Firstly, it is necessary to have a possibility of ensuring accurate and rapid reaction of the brake system to the initial command received from the automatic driver.

Secondly, the brake system should ensure identical braking efficiency with various changing loads of the train, to ensure stop-

ping of the train exactly at the required spot at any initial speeds during application of the brakes.

These requirements are most completely met by electropneumatic brakes combined with the automatic regulators of the pressure on the brake shoes depending upon the load of the cars that have been described above.

Brief characteristics of the state of automatic brake equipment on the railways.

As a result of becoming acquainted with the communications received from the various railway administrations several generalized characteristics of the automatic brake equipment in operation may be given.

On the absolute majority of railways, brakes with cast iron brake shoes are used with a maximum pressure of about 75 to 85 % of the light weight of passenger cars, 65 to 70 % of the light weight of empty goods vehicles and about 40 % of the weight of a loaded goods vehicle.

Most of the railways employ brakes with pneumatic control, the charging pressure in the train pipe being 5 kg per sq. cm, while a considerably smaller number use the more cumbrous and less efficient vacuum brakes.

The air distributors are the main part of the brake system, and a great variety of them, differing both in design and in the way of operation, including distributors only releasing action by stages or only in one stage, are met on the railways.

It should be noted that railways operating long trains prefer distributors with releasing in one stage, while railways having steep and long down grades prefer distributors with releasing of the brakes by stages.

In the new distributors for goods trains being employed on the railways (for example on the U.S.S.R. railways) two duties are provided for their action : *a*) mountain duty with releasing of the brakes by stages; *b*) plain duty with releasing in one stage.

Electropneumatic brakes are used mainly on suburban multiple-unit trains and only partly on long-distance passenger trains. In goods trains only test specimens are being used.

On a number of railways (Australia, Great Britain, the U.S.S.R., the U.S.A., Finland, etc.), there are being used to a considerable extent non-metallic brakes shoes with an increased coefficient of friction that only slightly depends upon the speed, and with lightened brake systems.

On various railways, compressor units are being used that differ from each other in their specifications, and information has been received on instances of an unsatisfactory quality of the compressed air in the brake pipes, when the air contained too much moisture and was contaminated with particles of compressor oil.

To ensure normal functioning of the brake systems the compressed air fed into the train pipe should be thoroughly cleaned of particles of oil and other substances, while its relative humidity should not exceed 80 to 85 %. When the humidity of the air is greater there may be instances when condensate precipitates if the temperature of the air drops by 1 to 2° C as a result of its throttling when passing through narrow orifices in the brake equipment. The condensate that has precipitated from the air, especially in winter operation conditions, may choke strictly calibrated openings in the automatic brake equipment. which may lead to its improper functioning.

Besides this the appearance of condensate in the train pipe causes corrosion of the latter with all the unpleasant results that ensue.

To dry the air fed to the train pipe the following should be undertaken :

a) cooling of the air with the aid of elongated delivery pipes or special coolers to a temperature exceeding the ambient temperature by not more than 2 to 3° C;

b) mechanical separation of the condensate, which creates a supersaturated condition of the air, and cleaning the latter

of admixtures of grease with the aid of special devices;

c) creation of a difference in pressure between the main reservoir and the train pipe for additional drying of the air as a result of its expansion when passing into spaces having a lower pressure.

The relative humidity of the air in the train pipe can be determined according to the formula :

$$\varphi = \frac{P_2 \cdot \gamma_1}{P_1 \cdot \gamma_2} 100 \ \%$$

where :

φ is the relative humidity of the air in %;

P_1 is the absolute pressure of the air in the main reservoir in atm.;

P_2 is the absolute pressure of the air in the train pipe in atm.;

γ_1 is the specific gravity of saturated water vapour at the temperature of the air in the main reservoir, kg per cu. m;

γ_2 is the specific gravity of saturated water vapour at the temperature of the air in the train pipe, kg per cu. m.

(Usually the temperature of the air in the train pipe is equal to the ambient temperature.)

Thus, by taking the desired value of the relative air humidity in the train pipe the required difference in pressure between the main reservoir and the train pipe can be determined. Or the expected relative humidity at any point in the brake system can be calculated for given conditions of operation of the compressor unit.

As calculations and the experience obtained in the operation of brake systems under various climatic conditions show, at a minimum pressure in the main reservoirs equal to 8 atm. and at a charging pressure in the train pipe of 5 atm. a relative humidity of the air in the brake system of 80 to 85 % will be ensured.

Upon comparison of the data regarding the braking distances permitted by various railways a great diversity is found in this important factor, which is connected with the safety of train operation and the traffic capacity of railway lines. The tolerated length of the braking distance determines the minimum distance tolerated between adjacent automatic block signals, and also determines the way of protecting by signals the places where there are obstacles to the movement of trains (the distance at which the signal indicating that a train must stop should be located from the place where there is an obstacle). The tendency of most of the railways is to obtain braking distances as short as possible, however this tendency is hindered by the limited possibilities afforded by the force of adhesion of wheels to the rails, as a result of which comparatively long braking distances have to be used in practice.

As a result of operation experience and experimental tests with trains it follows that with an account of winter operation conditions and the possibility of frequent atmospheric precipitation the railways can ensure a braking distance of 1 000 m upon emergency application of the brakes in a passenger train at an initial speed of 140 km/h and 1 200 m at an initial speed of 160 km/h with a guarantee that there will be no wedging of brakes. Further reduction of the braking distance is possible only on absolutely dry and clean rails or with the use of special rail brakes. The tolerated braking distances indicated above may be considered as optimum and as ensuring the safety of train operation at high speeds.

To ensure safe train operation with the established value of the maximum tolerated braking distance the permanent and temporary signals should be correspondingly located.

It is good, for example, to have the minimum distance between two adjacent automatic block signals equal the tolerated braking distance for service application of the brakes, bearing in mind that a train may approach a yellow light (caution aspect) of a three-aspect colour light signal at unrestricted speed. The braking distance for complete service application is usually about 20 to 25 % greater than for emergency application.

A portable signal should be located at a distance from the obstacle to train move-

ment which it is to protect that does not exceed the braking distance tolerated for emergency application of the brakes in a train.

In connection with the further increase in the speed of trains and the expediency of reducing the braking distances the problem of complete utilization of the force of adhesion of the wheels to the rails for braking acquires special importance. This problem is especially important for railways where low temperatures are encountered in winter, as well as a great amount of atmospheric precipitation, or other conditions under which the surface of the rails becomes dirty.

Up to the present, as can be seen from the communications of the various railways, the most widespread means of increasing the coefficient of adhesion of the wheels to the rails is the feeding of sand under the wheels of the locomotive. The most efficient would be such measures as the chemical or mechanical cleaning of the surfaces of the rails, as well as the use of electromagnetic rail brakes. However, these problems have been reflected in the form of small-scale experiments on separate railways, sufficient experience having not yet been accumulated for general recommendations and these problems require further investigation.

As a result of analyzing the development of automatic brake equipment it is necessary to note as deserving serious attention such objects of brake equipment as disk brakes and anti-sliding regulators.

However from the information received from the various railway administrations it is not possible to make any comments in respect to these elements of brake equipment.

Judging from the periodical publications experiments with disk brakes and anti-sliding devices are being carried out on the greatest scale on the U.S.A. railways. However, in this report it is not possible to consider any of the latest achievements in this field on the U.S.A. railways, as the U.S.A. railway administration did not find it possible to send in the required materials and information for this report.

In connection with the increase in the lifting capacity of goods vehicles and the increase in speed of passenger trains, difficulties are observed in the operation of lever brake rigging, as they become cumbrous.

Besides this, with the most widespread system of rigging with one brake cylinder and both side pressure, instances are noted in operation when the brake shoes are partly in contact with the wheels. As has been proved by the results of special investigations, this partial contact between the brake shoes and the wheels increases the specific resistance of cars by about 10 to 15 %, which naturally leads to excessive fuel consumption on the locomotives. Therefore the time has come when it is necessary to greatly improve the mechanical part of vehicle brake systems. Here, together with perfection of the system of brake shoe suspension, retaining springs, triangles and other parts, attention should be paid to the location of the brake cylinders in the brake system. On a number of railways there were attempts to replace the existing single brake cylinder with several cylinders located on each bogie or even with several brake cylinders per bogie. With such a solution of the problem the brake rigging is naturally simplified and lightened and instances of the brake shoes coming into contact with the wheels are eliminated in the best way. However a multiple-cylinder brake installation may increase to some degree the operating costs and the question of whether it pays to employ such installations on vehicles may be solved after a wide range of comparative tests in operation.

Conclusions and proposals.

Brake equipment is one of the most important items in the railway transport system, on the degree of development and condition of which the safety of train operation depends. The part played by the brake equipment grows more and more with an increase in the maximum train speeds, the weight and the length of trains.

The following technical propositions are recommended to be taken into account when continuing to perfect automatic brake equipment.

1) The braking efficiency of any unit of rolling stock should be designed with a view to realizing to the utmost the force of adhesion of the wheels to the rails for the condition of the rail surface that is most frequently encountered in practice.

2) The rated values of the coefficient of adhesion of the wheels to the rails when the brakes are applied should be defined more precisely with an account to the specific conditions on the railways of each country depending upon the speed of trains, the load on the wheels and other factors.

3) For passenger trains running at speeds over 120 km/h it is desirable to use anti-sliding regulators. However, brake systems with anti-sliding regulators should also be designed for the values of the coefficient of adhesion of the wheels to the rails most frequently encountered in operation. Upon designing a brake system with anti-sliding devices for too great braking forces, according to the conditions of adhesion of the wheels to the rails, cases are possible when during an emergency application of the brakes on dirty rails most of the anti-sliding regulators in the train will operate many times, as a result of which an undesirable increase of the braking distance may occur.

4) On railways where there are cold winters, there is considerable atmospheric precipitation or there are other constantly present factors that promote contamination of the rail surfaces, it is necessary to find ways and means of increasing the coefficient of adhesion of the wheels to the rails.

5) For high-speed trains, it is good to use non-metallic (plastic) brake shoes or disk brakes with a braking force that is almost independent of the train speed instead of the existing iron brake shoes.

6) It is desirable in the future to equip goods vehicles, as well as suburban train cars having a great varying load, with special regulating devices that will automatically change the pressure on the brake shoes depending upon the load of the car.

7) On railways where a considerable increase in train length and speed is planned for the future the trend should be to develop and employ electropneumatic control, which greatly improves train control with various brake duties being used and reduces the level of any possible longitudinal stresses in the train during applications of the brakes.

8) With diesel and electric traction, it is profitable to use electric (rheostat or recuperative) braking of locomotives, which permits to considerably increase the average speed of trains on long down grades and reduce the wear of the brake shoes.

9) To ensure faultless functioning of train brake systems, especially in winter operation conditions, the compressor installations of locomotives, besides an adequate output, should ensure sufficient drying of the compressed air and the removal of oil.

The compressed air is dried by cooling the air after compression before it leaves the main reservoir and creating a difference in pressure between the main reservoir and the train pipe of at least 2 kg per sq.cm. Oil is cleaned from the air with the aid of special oil catching devices.

10) Increase experimental work in respect to disk and rail brakes.

[65 .012 .1]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

18th SESSION (MUNICH, 1962).

QUESTION 7.

Application of operational research on the railways with particular reference to the purchase of material and stores, stores management and control of the quality of the purchases; traffic market research, etc.

REPORT

(America (North and South), Australia, Burma, Ceylon, Egypt, Finland, Ghana, West Germany, India, Indonesia, Irak, Iran, Republic of Ireland, Japan, Malaysia, New Zealand, Norway, Pakistan, Philippines, Siam, South Africa, Sudan, Sweden, Union of Socialist Soviet Republics, United Kingdom of Great Britain and Northern Ireland and dependent overseas territories),

by Dipl.-Ing. H. Jessen,

Ministerialrat bei der Hauptverwaltung der Deutschen Bundesbahn.

I. INTRODUCTION.

A specific definition of « operational research » (O.R.) was deliberately not provided in the questionnaire. It was merely explained, that we are dealing with the application of mathematical methods to questions of management at the intermediate and high level with a view of obtaining optimal results.

The replies received from railway administrations proved this to have been the correct way of approach. They also indicate ,that the railway administrations examined, whether, and to what extent, the problems arising may be solved with conventional, empiric methods without the application of O.R. It has become evident, that numerous railway administrations are not employing O.R. methods.

However, the large number of publications about O.R. methods for the solution of specific railway problems and the intended enlargement of O.R. departments and teams, where such are already existing, definitely indicate a general interest in O.R.

The report and its discussion during the 1962 Congress promise further progress and success for this mode of railway management.

II. QUESTIONS OF GENERAL ORGANISATION.

A. Questions of staff and organisation.

1) So far, only few railway administrations have established special O.R. departments, but there exist a large number of O.R. groups and working teams which, under the guidance or with the assistance of mathematicians, solve problems assigned to them by the various railway departments.

2) Most of these groups have no other

functions, but, in view of the versatility of the problems entrusted to them for mathematical solution they are compelled to engage in statistics, work studies, insurance mathematics, etc.

3) The O.R. groups range at high administrational level and are frequently directly responsible to the management.

Where O.R. groups are placed at intermediate level, they have special authority with regard to :

4) Submitting of reports and expert advice. In no case have they been responsible in the past for the implementation of the mathematical solutions which they found, and therefore, are not authorized to give directives.

5) The problems to be so studied are assigned to them by the top management, usually on request by any of the different railway sections.

6) The composition of the O.R. groups differs considerably with the individual railway administrations. However, most of these O.R. units consist of railway staff who are, on some railways, assisted by external consultants. Railway administration have only on rare occasions referred problems for study by O.R. methods to outside institutions (universities, public accountants).

7) Some of the railway administrations have each set up a central O.R. group and organised additional working teams according to requirements. Other railways, applying O.R. methods, form such groups whenever need arises :

8) For instance, to study problems concerning rail and road transport, procurement of stores, etc.

9) According to the replies received there are now 4 to 21 railway men per railway administration exclusively employed in O.R. This number is often considerably increased by temporary assignment of specialists and clerical help. Difficulties in recruiting graduates with mathematical qualifications have prevented the expansion of O.R. to a desirable extent.

10) O.R. teams assigned to one single problem consist of between four and six members.

11) In an attempt to accelerate their O.R., some railways have consulted private firms, public accountants, and college institutions but the results were found negligible and there is a notable tendency toward expanding their own O.R. groups.

12) There are hardly any public institutions which could advise the railways in regard to the set up and organisation of their O.R. groups.

The IIIrd. Committee of the International Railway Union (U.I.C.) have, as a subcommittee, organized a working group of mathematical experts.

In some cases the facilities of public statistical offices have been utilized.

The strongest influence appears to be exercised by industrial firms who are either selling or leasing modern business machines and computers.

B. Automatic calculating equipment.

13) Excepting conventional small business and calculating machines, no special computers have either been purchased or hired.

14) For data processing and evaluating, O.R. workers generally use the machines which the railways already possess or those available at other public offices, or time is hired on computers of private firms.

15) Electronic calculating machines, fitted with data storing devices are finding increasing use. The type of machines employed, so far as capacity is concerned, depends on the amount of work necessary from time to time.

16) Considerations similar to those under 15) above are governing also the methods of data collecting for O.R. and

17) the later transmission to data processing centers.

18) Most railways now have centralized punch card offices at regional level. Only

few administrations possess typewriters or business machines fitted with devices for producing teletapes or punch cards at the same time as the document is typed. However, it appears, that this modern method is increasingly employed for the purpose of rationalizing and accelerating O.R. work.

19) Only in special cases are punched data transmitted from their points of origin to processing centers. Ordinarily, such data are forwarded by railway mail service.

20) Automatic electronic devices for reading and transcribing data from punched tape to punched cards or magnetic tapes are not employed.

21) and 22) For better presentation, these questions are not considered here, because it has been stated under 13) already, that special machines have not been hired specifically for O.R. and because the fields of application are dealt with under III.

23) The replies to this question are substantially the same as those to question No. 4.

24) The value of computers in solving complex problems lies :

a) on the technical level, in getting optimal solutions in less time;

b) on the economic-financial level, in providing means for quicker and more simple assessment of the effects of modern methods, particularly where frequently repeating processes are concerned.

C. General evaluation of O.R.

25) All problems studied by O.R. methods have led to practical results, even if the investigations merely confirmed that the existing practices are correct. Also negative conclusions may be of value. Studies by O.R. methods are frequently of greater practical value than others, because acceptable interim solutions are found in shorter time.

26) *All* railway administrations, now employing O.R., are :

a) against any reduction in the number of staff engaged in O.R.;

b) no comments;

c) on the contrary endeavouring to increase the number of their O.R. staff, particularly where additional fields of application and problems which may be solved by O.R. methods are recognized.

In order to improve and accelerate O.R., the participation of mathematicians and mathematical statisticians is considered of special importance. Physicists and graduates in other fields involving mathematics are also deemed to make competent O.R. workers and there is a general consensus of opinion, that any railway man, having a talent for economic thinking and research may be successfully employed in O.R.

27) With regard to the O.R. methods listed under A to F it may be stated :

A) All railway administrations evaluate their statistics with good results.

B) Linear programming is more frequently employed than the methods under C to E.

C) The only other method used appears to be multiple regression, which, perhaps, is merely a different term.

28) and 29) All O.R. methods employed elicited good results (s. also 25) and the one most suitable in any individual case will be applied in the future.

30) Attached to this report is a catalogue of publications about O.R. subjects (Appendix No. 1).

III. GENERAL SURVEY OF SPHERES OF APPLICATIONS.

1) All railway administrations agree with the classification given in the questionnaire.

2) The following additional fields of application have been suggested :

f) optimation in the design of rolling stock;

g) determination of the economic mean service life of complete technical units, according to the method of Robly Winfrey.

(Note : By this method, almost all fields of railway activities may be investigated, excepting only administration.)

Referring back to items II. 21 and 22

I shall now report about the O.R. studies carried out or intended to be made by the various railway administrations :

1. Optimal distribution of empty wagons;

2. Approximated calculation of the number of net ton kilometers and passenger kilometers based on the number of wagons loaded and tickets sold and passenger revenues;

3. Operating methods and staff assignment;

4. Optimal composition of trains, having regard to the volume of traffic and the wishes of customers;

5. Efficiency in shunting and marshalling;

6. Economic timing of trains with regard to track alignment, curvatures and motive power;

7. Capacity of lines and yards;

8. Wagon turnround and measures for its improvement;

9. Cooperation of different marshalling yards;

10. Centralized and mechanized processing of transportation documents;

11. Periodic studies on the utilisation of locomotives and wagons;

12. Economics of the provision of first and second class accommodations in trains;

13. Economics of the movement of low-rated commodities by rail;

14. Correlation of rail movement with the trends of industrial and agricultural production;

15. Average lead of different commodities and wagon loads in the different distance zones;

16. Studies of the suburban traffic in large cities;

17. Optimal designs of carriages (number and size of doors, mean number of passengers boarding and alighting trains);

18. Control of stores in stock;

19. Causes and frequency of accidents;

20. Capacity of station platforms and approaches;

21. Ratio between smoker and non-smoker compartments;

22. Electric power consumption of trains.

IV. O.R. WITH REGARD TO PROCUREMENT, STORAGE, AND DISTRIBUTION OF SUPPLIES.

1. The reports received on the problems of the above important and costly branches of railway activities are especially interesting for a study of the possibilities offered by O.R., because they indicate wide differences of opinion. The methods now employed by most railway administrations for the procurement, storage and distribution of supplies are based on general financing principles. O.R. methods are seldom applied.

A number of railways are seriously studying whether O.R. would show solutions which would assist in attaining optimal efficiency on these three closely related sections. Fundamentally, they are convinced, that such solutions could be found through O.R. Some success has been already achieved, e.g., by the application of linear programming to the distribution of locomotive coal.

One association of a great number of railways applies O.R. methods

2. to all the problems related to the purchase and inventory control of stocks, under a) to f).

3. This association of railways gave no details on the various O.R. methods used but forwarded the below reproduced compilation with regard to the recordings made

and the methods and business machines employed :

« I. *Mechanized Inventory Procedures.*

A. Recording of annual inventory on punched cards.

B. Surplus or obsolescence reports from inventory.

II. *Mechanized Stock Control Procedures.*

A. Printing and preparation of stock records.

B. Updating stock records :

1. Of local stores;

2. Of general stores.

C. Stock status reports :

1. By store location;

2. By item.

III. *Mechanized Material Replenishment Procedures.*

A. Preparation of requisition or replacement notice for stock items :

1. By local stores :

a) on prepunched cards;

b) on unpunched cards.

2. By general stores :

a) on prepunched cards;

b) on unpunched cards.

B. Preparation of requisition for non-stock items :

1. By local stores :

a) on prepunched cards;

b) on unpunched cards.

2. By general stores :

a) on prepunched cards;

b) on unpunched cards.

C. Automatic replacement of stocks from punched charge cards :

1. From general stores to local stores;

2. From purchase orders prepared by use of charge cards.

D. Transfer of material between stores on punched cards.

E. Preparation of purchase orders :

1. By purchasing department :

a) mechanically prepared purchase orders from punched cards;

b) punched and purchase order;

c) by magnetic tape;

d) by tape or edge-punched card of typewriter.

2. By stores department :

a) mechanically prepared purchase order from punched card;

b) punched card purchase order;

c) by magnetic tape;

d) by tape or edge-punched card of typewriter.

IV. *Mechanized Allied Accounting Functions.*

A. Verifying receipt of material on punched cards.

B. Paying material invoices.

C. Charging out materials :

1. Expensive :

a) direct;

b) as disbursed.

2. Inexpensive :

a) direct;

b) as disbursed.

D. Distribution of charges for materials to proper accounts.

V. *Miscellaneous.*

Preparation of statistics from punched cards or tape :

1. Material stock balance;

2. Purchase commitment report;

3. Value of purchase by vendor;

4. Value of purchases by manufacturer;

5. Value of purchases by item;

6. Value of purchase by class. »

4. « for the most frequently needed stock items a perpetual inventory or strike-off system is employed to insure, that re-stocking procedures are set in motion, immediately stocks are reduced to the established minimum. The stock record on each item carries a maximum and a minimum.

On items of a special nature, such as construction of large and expensive installations, a representative of the stores department is assigned to follow through on all deliveries, controlling and adjusting them to changes in plans or to changes in progress of the work.

5. Special committees have been appointed for the purpose of studying the following subjects : warehousing, inventory control, standard packing, unit loads, visual report of actual application, simplification and standardization on car, locomotive and signal material, fuel and lubricants, crossties, reclamation, scrap disposition. ».

Following these verbal excerpts of the report of one railway association I shall now continue to relate the consolidated results of *all* reports.

6. Some railway administrations have their material supply service, particularly the « purchasing branch » *completely centralized*. Others have central and local stores supply offices and the responsibilities assigned to each of these are determined on carefully prepared codes or on past experience.

7. The data concerning deliveries, consumption, stocks on hand, etc. are secured by all three methods, namely :

a) manually;

b) by punched cards;

c) by electronic computers.

The methods under (*b*) and (*c*) are gradually gaining importance.

8. Inventory of stocks is taken when need arises but always in time to secure a steady flow of supplies.

9. Most railways furnish supplies to the consuming points at accounting prices which remain in force for relatively long periods of time and are changed only if there are large fluctuations in purchasing prices. « Genuine » prices rather than accounting prices are applied only by railways who are employing for their material supply *and* storage service electronic computers which perform the necessary laborious arithmetic.

10 to 12. Most of the railways gave no reply to this question, because it seems impossible to determine the percentage of cost attributable to the supply and storage of material.

13. The turnover or cycle of rotation differs for the single items of supplies so much that it could hardly be expressed in figures. Most railways have a fixed minimum and maximum number for each item.

14 to 18. Regarding the use made by the railways of O.R. methods for the purchase, storage, distribution, etc. of supplies I wish to refer to 1) and 3). No doubt, O.R. could be applied to many spheres of the supplies service and a study of these fields is important in order to keep step with technical progress and the continuously changing problems of the market and consumption. However, officials responsible for the purchase, storage, distribution, etc. of supplies will continue to be indispensable.

V. APPLICATION OF OPERATIONAL RESEARCH TO THE QUALITY CONTROL OF PURCHASES.

1. The inspection of new rolling stock, railway plant, installations and supplies is, in general, carried out by the railways' own inspectors who are assisted in their work by the railway's chemical, physical, metallurgical, and mechanical testing laboratories and who cooperate with the supplier's inspectors.

Where supplies are obtained from other countries, arrangements are made for quality inspections to be carried out by the national railway or by private firms.

Simple goods and consumable items are checked on receipt at the storage depot.

A few railways hold the supplier responsible for the quality of their products.

2. All the methods mentioned are applied, but O.R. teams are seldom employed for this work.

b 1) Where supplies are delivered in large numbers it is not usual to inspect each single item, but this depends upon the high value of the article or its importance to operating safety, for instance : coloured glasses for signals, insulators, etc.

b 2) Only few railways employ the mathematical statistical method for inspections and, as indicated by their reports, have secured savings both for the railway and the supplier. Several railways intend to apply this method for certain items.

b 3 and *b* 4) It seems impossible to prepare lists of supplies for which these two methods of inspection may be employed.

3. *a*) *All* railway administrations use X-ray examination in inspecting : boiler welds, other weldings, and large size castings;

b) radioactive isotopes are not yet used for material inspection:

c) ultrasonic inspections are made of axles, insulators, etc.;

d) practically all railways make use of surface tests.

VI. APPLICATION OF OPERATIONAL RESEARCH TO THE TRANSPORT MARKET.

At the outset I may quote the critical remarks made by *one* railway administration : « Market research, as defined in the questionnaire, is not considered part of operational research, nor is such research undertaken by the O.R. unit. At both central and regional management levels some aspects of market research are undertaken in the traffic intelligence sections while others may be dealt with in economics or economic survey sections. »

Other railways have not emphasized that they clearly differentiate between O.R. methods and the evaluation of statistical data by the department concerned (commercial department), but the reports received gave only few indications, that O.R. methods are applied to market research.

1. Almost all railway administrations analyse the market, using besides their own statistics also other business and official statistics. Questions concerning :

c) living habits;

d) occupation;

e) housing;

are often not included in these studies, because they are considered to have little bearing on the traffic volume.

However, one railway which carries immense suburban traffic is studying the subjects under (*c*) and (*e*) very carefully and estimates the demand for travel on their lines by :

housing completions;

cinema admissions;

attendances at sporting events;

weather conditions, etc.

In countries with planned economy, the railways are receiving the necessary data from the planning authorities and are given advance information about planned future development.

2. Almost all railway administrations study the dynamic forces influencing the market. The observations made at regional level are usually evaluated at one central point.

3. The same applies to studies of the market trend. Factors affecting the market. such as : trend of trade, productivity of industry, world economy are registered and analized. Long-range forecasts are made on own behalf and on request of governmental bodies. The volume of traffic has been calculated by using historically estimated regression coefficients and by applying prognosis values of interpreting variables.

4. Most of the railway administrations have studied the factors responsible for the diversion of traffic from the railways to other types of transport. One railway has ordered their research organ for traffic economics to explain « how the demand on the services of the different carriers is influenced by prices and income ».

One railway administration reported, as

an exception, that they are not conducting such studies, since they are offered more traffic than they can handle.

5. For market research in the transport sector the following methods were applied :

simple and multiple correlation method;

comparisons between the relative cost and tariffs;

quota sampling system, using questionnaires;

census of passengers on sample basis, etc.

6. While public opinion polls have been frequently undertaken with regard to passenger traffic, they were not deemed necessary for goods traffic, excepting only in a few cases.

7. See reply under 6 above.

8 and 9. Railway administrations have sent out questionnaires of their own only on rare occasion. For lack of qualified own personnel they referred such projects in most cases to market research firms.

10 and 11. Railway administrations, already engaged in market research are generally of the opinion that there are possibilities for further successful developments and that O.R. and mathematical-logistic methods will improve the results.

VII. APPLICATION OF THE OPERATIONAL RESEARCH TO OPERATING AND MAINTENANCE PROBLEMS.

1. So far, *no O.R. methods* have been used for determining optimal cycles of routine maintenance and repairs. However, some railways are already collecting data for later evaluation by O.R. methods.

2. Production schedules of workshops are arranged in the way most suitable for the individual shops.

3. One railway administration has made extensive investigations into the capacity of lines in terms of frequency of service, journey speed, and passenger carrying capacity. In order to programme upper speed limits more suitable for reducing journey times, another railway administration has made technical calculations for the purpose of relating rolling stock performance to route characteristics and desired train schedules.

4. While most of the railways stated that they have adequate knowledge of the capacity of their means of transport and installations, one railway reported, that such studies will be included in the programme for their O.R. unit.

5 to 8. No O.R. methods have yet been applied for the study of these problems.

9. Some railways have obtained valuable results in applying linear programming for the study of utilization and distribution of empty wagons. One railway considers the transit of loaded wagons as the main function of their system which should be studied by O. R. methods.

10 and 11. At some railways, studies by O.R. methods are under way to determine the optimal location of stabling sidings.

12. The railways who have already set up O.R. units are generally of the opinion, that an extension of studies by O.R. methods to other railway subjects is necessary and will produce valuable results.

The various proposals made will be found under III. 2.

APPENDIX.

Catalogue of publications by the various railways and bibliography of O.R. subjects.

Finnish State Railways.

1. « Optimal Programming for the Distribution of Empty Cars » (linear programming, 1957).

2. « The Economy of L.C.L. traffic on the Finnish State Railways » (1960).

In this study linear programming was applied to show how discontinuing of L.C.L. shipments would influence the distribution of empty cars. For the study of other problems, multiple regression was used.

3. « The Economical Aspects of Lines Carrying Little Traffic » (partly linear programming, partly multiple regression, 1960).

4. « A Model Showing How the Cost on the Railways Correlate to Different Factors and the Application of this Model to Various Cost Calculation Problems » (multiple regression, 1960).

5. « Some Possibilities for Applying Regression Analysis in Planning and Controlling the Use of Lorries of the Finnish State Railways » (multiple regression, 1960).

6. « The Influence of Various Factors on the Maintenance Cost for the Class Tk 3 Steam Locomotives. »

London Transport Executive.

1. P. I. WELDING. — « Instability of a Close-Interval Service », Operational Research Quarterly, Vol. 8, No. 3 (1957).

2. B. D. HANKIN and R. A. WRIGHT. — « Passenger Flow in Subways », Operational Research Quarterly, Vol. 9, No. 2 (1958).

3. P. I. WELDING and J. STRINGER. — « A Problem in Vehicle Fuel Consumption », Operational Research Quarterly, Vol. 11, No. 4 (1960).

4. B. D. HANKIN. — « Operations Room Technique in Operational Research », Operational Quarterly, Vol. 11, No. 4 (1960).

British Transport Commission.

1. « Does Operational Research Help », Traffic Research Quarterly, No. 6, January 1952.

2. « Operational Research in British Transport », British Transport Review, Vol. VI, No. 1, August 1960.

German Federal Railway.

1. « The Application of Linear Programming to Determine the Optimal Turnround of Empty Wagons on the German Federal Railway » (« Zeitschrift für die gesamte Staatswissenschaft », Vol. 1, 1959).

2. « Application of Sampling Methods Saves Train Working Cost » (« Archiv für Eisenbahntechnik », Vol. 11, 1958).

3. KÜMMELL. — « Size and Location of Marshalling Yards » (« Rangiertechnik », Consolidated Vol., page 13).

4. CAUER. — « Location and Traffic Functions of Marshalling Yards » (Ebenda, page 3).

5. GRASSMANN. — « Some Thoughts about the Relation between Settlement Projects and Marshalling Yards » (Bundesbahn 1957, page 1124).

6. KLEIN. — « Saturation Limits in Case of Complete Automatization of the Humping Zones » (Rangiertechnik 13/1953).

7. GRASSMANN. — « The Maximum Capacity of Marshalling Yards » (Rangiertechnik 17/1957, page 24).

8. ROSTECK. — « The Application of a Scale to Determine the Capacity of Marshalling Yards » (Rangiertechnik 18/1958, page 14).

9. AMMANN. — « A Critical Review of a Marshalling Yard Layout and its Influence on Performance » (Verkehrstechnische Woche 1919, page 269).

10. BAUMANN. — « How the Length of Trains Affects the Efficiency and the Amount of Work Necessary in Marshalling Yards » (Organ Fortschritte des Eisenbahnwesens 1922, page 249).

11. FICKERT. — « Double Humping Increases Capacity of Marshalling Yards » (Rangiertechnik, Vol. 17/1957, page 35).

12. LEIBBRAND. — « The Performance Limit of Humping Installations » (Organ Fortschritte des Eisenbahnwesens 1938, No. 14).

13. LEIBBRAND. — « How to Increase the Capacity of Marshalling Yards » (Verkehrstechnische Woche, 1938, No. 11).

Extract from Railway Literature.

1. « Use of an Electronic Computer in Train Operations » (Jap. Rly. Eng, 1, 1960, 5, pages 22 to 24, 4 B).
A method employed by the Japanese National Railways for the determination of the elements of a train run with an analogue computer and an electronic computer. Further possibilities for the practical application of this device (S.N.C.F.).

2. « Electronic Computers Used for Long Term Advance Calculations of the Flow of Wagons » (Maksimovic and others, Zeleznodor. Transport, 1960, 10, pages 32 to 35, 4 B, Russian).

A detailed description of the method employed by the Soviet Railways for calculating the wagon flow of an important railway junction for one, two or three days in advance with the use of electronic data processing machines. Advance calculations made as a test for the Swerdlowsk junction; time expended for these calculation; calculation results. Improvements of the devices used for transmission of the basic data are said to reduce the time required for such advance calculations (S.N.C.F.).

Fondation Internationale Balzan.

We think advisable to inform our readers of the recent establishment of the « Fondation Internationale Balzan ».

This undertaking, which started its activities on November 16, 1961, grants every year prizes to encourage and sustain the most deserving efforts in the humanitarian, social and scientific field. Amongst the three prizes granted every year, one will be attributed to sciences (physics, chemistry, engineering and medecine).

Exceptionally, the number of prizes may be increased to four or five. The Balzan Foundation is also able to honour particularly deserving achievements in the field of technical research.

The « Fondation Internationale Prix E. Balzan-Fonds » is under the supervision of the Swiss Federal Department of the Interior (Switzerland), Bern.

MONTHLY BIBLIOGRAPHY OF RAILWAYS (1)

PUBLISHED UNDER THE SUPERVISION OF

P. GHILAIN,

General Secretary of the Permanent Commission of the International Railway Congress Association.

(NOVEMBER 1961)

[**016** .385 (02]

I. — BOOKS.

In French.

1961 **531**
BRONDEL (J.).
Accouplements, joints de Cardan, encliquetages.
Paris, Dunod, éditeur. Un volume (16 × 25 cm) de XI + 451 pages, avec 476 figures. (Prix : relié, 64 NF.)

1961 **691**
MAURIN (A.J.).
Manuel d'anticorrosion. Tome I : *Introduction à l'esprit de la technique d'anticorrosion.*
Paris (5e), Eyrolles, éditeur, 61, boulevard Saint-Germain. Un volume (16 × 25 cm) de 350 pages, avec 100 figures. (Prix : 60 NF.)

1961 **669**
Dipl.-Ing. W. ORDINANZ.
Introduction à la trempe. Traduit de l'allemand par Ph. LION et C. CHAUSSIN.
Paris, Dunod, éditeur. Un volume (14 × 22 cm) de XI + 284 pages, illustré. (Prix : broché, 24 NF.)

1961 **51**
SALLES (F.).
Initiation au calcul opérationnel et à ses applications techniques. *2e édition.*
Paris, Dunod, éditeur. 76 pages (16 × 25 cm), avec 76 figures. (Prix : broché, 4.80 NF.)

In German.

1960 **55**
BRINCH HANSEN (J.) und LUNDGREN (H.).
Hauptprobleme der Bodenmechanik.
Berlin, Göttingen, Heidelberg, Springer-Verlag. Ein Band 8°, XII-282 Seiten, mit Abbildungen. (Preis : DM 36.—.)

1961 **624**
Prof. Dr.-Ing. B. FRITZ.
Verbundträger. Berechnungsverfahren für die Brückenbaupraxis.
Berlin-Göttingen-Heidelberg, Springer-Verlag. 149 Seiten (18 × 25 cm) mit 82 Abbildungen. (Preis : DM 31.50.)

1960 **721 .9**
Dr.-Ing. Otto F. THEIMER.
Hilfstafeln zur Berechnung wandartiger Stahlbetonträger. *3. Ausgabe.*
Berlin, Verlag von Wilhelm Ernst & Sohn. Ein Band (17 × 24 cm), 47 Seiten, 23 Abbildungen und 15 Tafeln. (Preis : DM 8.60.)

1961 **62 (01**
Dr.-Ing. A. WEIGAND.
Einführung in die Berechnung mechanischer Schwingungen.
Berlin. VEB Verlag Technik.
Band I : Format DIN A 5, 124 Seiten, 58 Abbildungen. (Preis : Kunstleder, DM 9.—.)
Band II : Format DIN A 5, 176 Seiten, 67 Abbildungen, 12 Tafeln. (Preis : Kunstleder, DM 21.—.)

In English.

1961 **385 (42)**
London Transport in 1960.
One brochure of 97 pages, illustrated, published by the London Transport Executive, 55, Broadway, Westminster, London S.W. 1. (No price stated.)

1961 **656 (01**
HAY (W.W.).
An introduction to transportation engineering.
One volume of 515 pages, illustrated.
London : John Wiley & Sons Ltd., Gordon House, Greencoat Place, S.W. 1. (Price : 94 s.)

1961 **656**
SAMUEL (H.).
Railway operating practice.
One volume of 256 pages, copiously illustrated.
London : Odhams Press Ltd., 96, Long Acre, W.C. 2. (Price : 30 s.)

(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels, (See « Bibliographical Decimal Classification as applied to Railway Science », by L. WEISSENBRUCH, in the number for November 1897, of the *Bulletin of the International Railway Congress*, p. 1509).

[**016** .385 (05]

II. — PERIODICALS.

In French.

Acier - Stahl - Steel. (Bruxelles.)

1961 **624**
Acier - Stahl - Steel, septembre, p. 379.
VERDEYEN (J.) et ROISIN (V.). — **Le calcul pratique des rideaux de palplanches métalliques.** (8 000 mots & fig.)

1961 **62** (01
Acier - Stahl - Steel, septembre, p. 401.
DUTHEIL (J.). — **L'évolution des méthodes de calcul.** (2 500 mots & fig.)

Annales des Ponts et Chaussées. (Paris.)

1961 **62** (01
Annales des Ponts et Chaussées, juillet-août, p. 441.
LEGENDRE (R.). — **Solutions exactes de quelques problèmes d'élastostatique plane.** (1 200 mots, tableaux & fig.)

1961 **656** .23
Annales des Ponts et Chaussées, juillet-août, p. 489.
LHERMITTE (P.). — A propos de la **tarification des services publics.** (10 000 mots & fig.)

1961 **721** .1
Annales des Ponts et Chaussées, juillet-août, p. 523.
PAYAN (G.). — Etude géométrique des **fondations sur pieux.** (6 000 mots et fig.)

Annales des Travaux Publics de Belgique. (Bruxelles.)

1961 **55**
Annales des Travaux Publics de Belgique, n° 2, avril, p. 105.
LADANYI (B.). — **Etude théorique et expérimentale de l'expansion dans un sol pulvérulent d'une cavité présentant une symétrie sphérique ou cylindrique.** (*A suivre.*) (15 000 mots, tableaux & fig.)

Bulletin de Documentation S.C.E.T.A. (Paris.)

1961 **656** .132
Bull. de Documentation S.C.E.T.A., septembre-octobre, p. 1.
Chauffage et climatisation des autocars et autobus. (5 000 mots & fig.)

Bulletin de la Société Française des Electriciens. (Paris.)

1960 **621** .
Bulletin de la Société Française des Electriciens, ju
p. 352.
BOURDON (R.). — **Mise au point des accesso de canalisations souterraines à moyenne et à basse t sions.** (3 800 mots & fig.)

Bulletin des Transports Internationaux par Chemins de fer. (Berne.)

1961 **656** .
Bull. des Transp. Intern. par Ch. de fer, juillet-ac
p. 167.
MÁTYÁSSY (Z.). — **Conditons spéciales pour transport des denrées périssables.** (4 000 mots.)

Bulletin de l'Union Internationale des Chemins de fer. (Paris.)

1961 **385**
Bull. de l'Union Intern. des Chemins de fer, juil
août, p. 244.
Les problèmes économiques des Chemins de fer pays membres de la Conférence Européenne des Minis des Transports. Résumé du rapport présenté par l'Un Internationale des Chemins de fer à la Confére Européenne des Ministres des Transports. (4 000 mo

1961 **385** .113
Bull. de l'Union Intern. des Chemins de fer, juil
août, p. 253.
Les Chemins de fer en 1960. (Norvège, Suède.) (5 mots & tableaux.)

C.F.F. (Berne.)

1961 **656** .21 (
C.F.F., septembre, p. 3.
GRABER (E.). — **Les gares d'Airolo et de Goesche dotées d'installations modernes.** (2 000 mots &

1961 **656** .2 (
C.F.F., septembre, p. 8.
KRONAUER (A.). — **L'exploitation de la ligne Saint-Gothard** sur son parcours de montagne. Evolu présente et future. (1 500 mots & fig.)

1961 **624** (
C.F.F., septembre, p. 15.
BECKER (R.). — A propos de la transforma des **grands ponts du Saint-Gothard.** (1 000 mots &

1961 656 .25 (494)
.F.F., septembre, p. 17.
LEEMANN (R.). — **De nouvelles installations de** **ecurité accroissent la capacité du tunnel du Saint-Gothard.** 200 mots & fig.)

1961 656 .25
.F.F., septembre, p. 20.
WINTER (P.). — La **signalisation de vitesse.** Principe : application. (2 500 mots & fig.)

Le Génie Civil. (Paris.)

1961 621 .31 (44)
e Génie Civil, nº 3547, 1er septembre, p. 354.
BERTRON (L.) & MARCAILLOU (J.). — **Le démar-** **ıge par by-pass des groupes turbo-alternateurs de 125 MW** la centrale thermique de Lacq-Artix (Basses-Pyrénées). 000 mots, tableaux & fig.)

1961 624 .51 (44)
e Génie Civil, nº 3547, 1er septembre, p. 366.
Le **pont suspendu** de la Roche-Bernard sur la Vilaine. 500 mots & fig.)

1961 625 .13 (43)
e Génie Civil, nº 3548, 15 septembre, p. 378.
MORHARD (W.). — **La construction du tunnel du** **létropolitain de Hambourg sous les voies ferrées de la** **are centrale.** (3 000 mots & fig.)

L'Industrie des Voies ferrées et des Transports automobiles. (Paris.)

1961 625 .6 (06
'Ind. des Voies fer. et des Transports automobiles, juillet-août, p. 102.
CASSAN. — **XXXIVe Congrès International de** **U.I.T.P.** Copenhague, mai 1961. (6 000 mots & fig.)

₹evue Générale des Chemins de fer. (Paris.)

1961 656 .254
.evue Générale des Chemins de fer, septembre, p. 473.
TROGNEUX. — **Le téléphone sélectif aux chemins** **e fer.** Son évolution. (9 000 mots & fig.)

1961 625 .258 (44)
.evue Générale des Chemins de fer, septembre, p. 490.
TESSIER. — **Levage des freins de voie lourds** à la égion de l'Ouest de la S.N.C.F. par portiques mobiles équipement électrique. (1 500 mots & fig.)

1961 621 .335 (44)
.evue Générale des Chemins de fer, septembre, p. 495 et p. 498.
Les automotrices électriques « tous services » de la **.N.C.F.** Exposé général, par J. ROQUES. (1 000 mots : fig.)
L'automotrice électrique type Z 7100, par R. LE BERRIGAUD et J.P. MEILHAT. (4 000 mots, tableaux & fig.)
Les remorques pour automotrice Z 7100, par M. AMIEL. (1 500 mots & fig.)

1961 656 .222 .5 (4)
Revue Générale des Chemins de fer, septembre, p. 515.
Mise en service de **nouvelles relations « Trans-Europ-Express » électriques :** Paris-Milan, Zurich-Milan, et vice versa. (1 000 mots & fig.)

1961 625 .42 (44)
Revue Générale des Chemins de fer, septembre, p. 518.
Ouverture des **travaux de la traversée sous-fluviale de la ligne Est-Ouest du Réseau express régional** de la Régie Autonome des Transports Parisiens (R.A.T.P.). (800 mots & fig.)

1961 385 (09 (45)
Revue Générale des Chemins de fer, septembre, p. 522.
LARTILLIEUX (H.). — Les **Chemins de fer Italiens :** réalisations techniques — situation générale. (1 500 mots & carte.)

1961 621 .431 .72 (43)
Revue Générale des Chemins de fer, septembre, p. 528.
La **traction Diesel-hydraulique** sur le Chemin de Fer Fédéral Allemand. (2 000 mots & fig.)

La Traction Electrique dans les Chemins de fer. (Bruxelles.)

1961 621 .431 .72
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, nº 7, juillet, p.311.
ATTOCK (M.O.) et FLETCHER (S.). — Quelques idées sur l'entretien des **locomotives Diesel électriques.** (8 700 mots & fig.)

1961 621 .431 .72 (43)
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, nº 7, juillet, p.336.
LUDWIG (H.). — Les dispositifs de commande de la **locomotive Diesel** V 60. Perfectionnements aux appareils de commande. (3 500 mots & fig.)

1961 621 .391 (73)
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, nº 7, juillet, p.349.
Automatisation des engins de traction. (2 200 mots & fig.)

1961 621 .336 (47)
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, nº 7, juillet, p.358.
Attaches russes pour **lignes caténaires,** (300 mots & fig.)

1961 621 .335 (73)
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, nº 7, juillet, p.360.
Le Pennsylvania Railroad reçoit la première unité d'une nouvelle série de **locomotives électriques.** (500 mots & fig.)

La Technique Moderne. (Paris.)

1961 **621** .9 (06 (493)
La Technique Moderne, août, p. 308.
La Septième Exposition Européenne de la Machine-Outil. Bruxelles, 3-12 septembre 1961. (4 000 mots & fig.)

Les Transports Publics. (Berne.)

1961 **625** .6 (494)
Les Transports Publics, septembre, p. 3.
La situation de nos chemins de fer privés. (Suisse.) (1 200 mots.)

La Vie du Rail. (Paris.)

1961 **656** .211 .7 (45)
La Vie du Rail, 10 septembre, p. 3.
SCARSINI (G.). — Naissance d'un **nouveau service ferry** Civitavecchia-Golfo-Aranci. (1 000 mots & fig.)

1961 **656** .211 .5 (44)
La Vie du Rail, 10 septembre, p. 10.
Nouveaux aménagements de la gare banlieue Paris-Orsay. (500 mots & fig.)

1961 **385** (09 (66)
La Vie du Rail, 10 septembre, p. 22.
Prolongement du chemin de fer du Dahomey vers le Niger. (800 mots & carte.)

1961 **625** .245 (44)
La Vie du Rail, 17 septembre, p. 17.
PEIGNE (R.). — **278 tonnes sur un wagon.** (900 mots & fig.)

1961 **656** .222 .5 (460)
La Vie du Rail, 17 septembre, p. 20.
CABRERA (J.B.). — **Mise en service du train « TALGO » sur les lignes Madrid-Barcelone et Madrid-Séville.** (1 000 mots & fig.)

In German.

Die Bundesbahn. (Darmstadt.)

1961 **656** (43)
Die Bundesbahn, Nr. 15, August, S. 643.
OEFTERING (H.M.). — **Das Problem der Kontingentaufstockung im Güterfernverkehr.** Eine Möglichkeit zu schöpferischer Verkehrspolitik. (4 000 Wörter.)

1961 **656** .222 .4
Die Bundesbahn, Nr. 15, August, S. 650.
ZWERNEMANN (W.). — Verfahren zur **Ermittlung der Leistungsfähigkeit zweigleisiger Strecken durch Berechnung der Mindestzugfolgezeiten.** (6 000 Wörter, Tafeln & Abb.)

1961 **656** (4
Die Bundesbahn, Nr. 15, August, S. 662.
DIETRICH (A.). — Der Wegfall des Widerspruc verfahrens im neuen **Personenbeförderungsgesetz.** (3 0 Wörter.)

1961 **656** .222 .5 (49
Die Bundesbahn, Nr. 15, August, S. 695.
Neue elektrische TEE-Züge der Schweizerisch Bundesbahnen. (1 000 Wörter & Abb.)

Deutsche Eisenbahntechnik. (Berlin.)

1961 6
Deutsche Eisenbahntechnik, August, S. 373.
POTTHOF (G.). — **Die mathematische Logik a Grundlage der Betriebsführung.** (3 000 Wörter, Tafe & Abb.)

1961 **625** .
Deutsche Eisenbahntechnik, August, S. 379.
WIESSNER (M.). — Allgemeine Fragen der **E wicklung und Fertigung von Reisezug- und Triebwage** (3 500 Wörter & Abb.)

1961 **625** .23 & **669** .
Deutsche Eisenbahntechnik, August, S. 384.
MICHEL (G.) und GRAHL (F.). — **Aluminiu Reisezugwagen** auf der Leipziger Frühjahrsmesse. (8 Wörter & Abb.)

1961 **625** .143
Deutsche Eisenbahntechnik, August, S. 385.
GILBERT (E.) und ZAREMBA (J.). — Die **Bea spruchung von Eisenbahnschienen.** (6 000 Wörter, Tafe & Abb.)

1961 **625** .
Deutsche Eisenbahntechnik, August, S. 399.
TEUFEL (M.). — **Die Verschleissuntersuchung an Triebfahrzeugen.** Die Praxis der Verschleissunte suchungen an den Triebfahrzeugen der Deutsch Reichsbahn und eine Vorschau auf die zu erwartet Verschleiss-Kennzahlen. (6 000 Wörter, Tafeln & Ab

---

1961 **625** .2
Deutsche Eisenbahntechnik, August, S. 409.
GRUSS (A.). — **Versuche mit dem Druckölverfahr an Eisenbahnradsätzen.** (*Fortsetzung folgt.*) (3 000 Wört Tafeln & Abb.)

Der Eisenbahningenieur. (Frankfurt am Mai

1961 **624** .
Der Eisenbahningenieur, September, S. 244.
RODE (K.). — **Tunneluntersuchungen — Tunnelme einrichtungen.** (5 000 Wörter, Tafel & Abb.)

1961 **625** .2
Der Eisenbahningenieur, September, S. 252.
HEROLD (C.). — **Rationelle Behandlung der Ra sätze** von Schienenfahrzeuge. (5 000 Wörter & Ab

1961 695
er Eisenbahningenieur, September, S. 263.
TSCHIESCHE (W.). — **Schallschluckende und akustik-rbessernde Decken aus Metall.** (2 500 Wörter, Tafeln Abb.)

E.T.R.-Eisenbahntechnische Rundschau. (Darmstadt.)

1961 **621** .791
senbahntechnische Rundschau, August, S. 323.
AHLERT (W.). — **Weitere Verbesserungen und inter-tionale Ausbreitung der modernen THERMIT-Schienen-hweissung.** I. Teil. Weitere Verbesserungen der moder-n THERMIT-Schienenschweissung. (6 000 Wörter, afeln & Abb.)

1961 **725** .31 (43)
isenbahntechnische Rundschau, August, S. 337.
GERBL (H.). — Der **Wiederaufbau des Empfangs-ebäude** des Münchener Hauptbahnhofs. (5 000 Wörter Abb.)

1961 **54** (43)
isenbahntechnische Rundschau, August, S. 362.
PRAGST (W.), WISCHERT (W.), SANDKE (R.), OMMER (E.A.), HENTZSCHEL (R.), SCHNEI-ER (E.), MAULER (Th.) und KÜSTER (H.). — **Die hemie im Dienste der Deutschen Bundesbahn** insbeson-ere bei dem Chemischen Versuchsamt Bückeburg. 000 Wörter & Abb.)

1961 **625** .282 (73)
isenbahntechnische Rundschau, August, S. 376.
KUNER (A.). — **4 000-PS-C'C'-Krauss-Maffei-Diesel-komotive für die USA** und ihre Vorführung auf der mmeringbahn am 3. bis 7. Juli 1961. (1 500 Wörter Abb.)

1961 **656** .222 .6
isenbahntechnische Rundschau, August, S. 380.
KRUGMANN (H.-L.). — **Wie begrenzt die Festigkeit r Zugeinrichtung die Auslastung der Güterzüge.** (1 000 Vörter & Abb.)

Elektrische Bahnen. (München.)

1961 **621** .335
ektrische Bahnen, Heft 7, S. 145.
GLADIGAU (A.). — Untersuchung über die **Achsent-stung bei elektrischen Lokomotiven mit zweiachsigen rehgestellen.** (7 800 Wörter & Abb.)

1961 **621** .335
ektrische Bahnen, Heft 7, S. 161.
BÄCHTIGER (A.). — **Betriebserfahrungen mit neu-tigen Bo'Bo'Bo'-Schmalspurlokomotiven grosser Leis-ng.** (2 200 Wörter & Abb.)

Elektrotechnik und Maschinenbau. (Wien.)

1961 **621** .316
Elektrotechnik und Maschinenbau, September, S. 504.
WAGNER (A.). — **Ableitung von Formeln für einpoligen Erdschlussstrom an Doppelleitungen.** (400 Wörter & Abb.)

Internationales Archiv für Verkehrswesen. (Frankfurt am Main.)

1961 **656** .222 .5
Internationales Archiv für Verkehrswesen, August, S. 255.
LEHNER (F.). — Der **öffentliche Nahverkehr** im Rahmen der städtischen Generalverkehrspläne. (4 000 Wörter.)

1961 **656** (06 (4)
Internationales Archiv für Verkehrswesen, August, S. 261.
KRAUSS (G.). — Die Leitgedanken der Kommission der Europäischen Wirtschaftsgemeinschaft zur **gemeinsamen Verkehrspolitik.** (7 000 Wörter.)

1961 **656** (4)
Internationales Archiv für Verkehrswesen, August, S. 270.
KÜPER (F.M.). — **Europäische Zusammenarbeit in der Verkehrstechnik** als verkehrswissenschaftliche Aufgabe. (3 500 Wörter.)

Der Öffentliche Verkehr. (Bern.)

1961 **625** .6 (494)
Der Öffentliche Verkehr, September, S. 3.
Die Lage der schweizerischen Privatbahnen anhand der neuesten Geschäftsberichte. (1 700 Wörter & Tabellen.)

Siemens-Zeitschrift. (Berlin.)

1961 **621** .316
Siemens-Zeitschrift, August, S. 598.
MEILER (B.) und RAUCH (W.). — **Selektivität von Installations-Schaltgeräten.** (2 000 Wörter & Abb.)

1961 **656** .254 (43)
Siemens-Zeitschrift, August, S. 622.
FUNKE (W.). — **Selbsttätige Zuglenkung bei der Hamburger S-Bahn.** (450 Wörter, 2 Abb.)

Signal und Draht. (Frankfurt am Main.)

1961 **656** .253
Signal und Draht, August, S. 113.
SCHULZ (H.). — **Einheitliche Blinklichtanlagen mit Fernüberwachung** (Fü 60) an ein- und zweigleisigen Bahnen. (4 000 Wörter & Abb.)

1961 **656** .212 .5
Signal und Draht, August, S. 120.
SCHMITZ (W.). — **Falschläufer in selbsttätigen Ablaufstellwerken.** (*Fortsetzung folgt.*) (3 000 Wörter & Abb.)

Verkehr. (Wien.)

1961 **656** .235 (42)
Verkehr, 26. August, S. 1197; 9. September, S. 1275.
ZIPPERT (W.). — **Die Gütertarife der Britischen Eisenbahnen** im Binnen- und internationalen Verkehr. (2 900 Wörter & Abb.)

Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden. (Dresden.)

1960/61 **624** .2
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 245.
REICH (O.). — **Die Biegetheorie für Sandwichbalken.** Teil I und II. (4 000 Wörter & Abb.)

1960/61 **656** .222 .5
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 255.
POTTHOFF (G.). — **Der regelmässige Fahrplan.** (4 000 Wörter, Tafeln & Abb.)

1960/61 **656** .225
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 263.
KURZ (H.). — **Kombiniertes Ladesystem für Schütt- und Stückgut.** (1 600 Wörter & Abb.)

1960/61 **625** .28
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 267.
HOCHMUTH (A.). — **Der Haftgrenzwert und sein Einfluss auf die Mechanik der Zugförderung.** (5 000 Wörter & Abb.)

1960/61 **621** .134 .1
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 285.
SCHIMMING (H.) und UHLICH (S.). — Beitrag zur **Beurteilung des Verschleissverhaltens von Kolbenschieberringen und Schieberbuchsen** bei Dampflokomotiven. (5 000 Wörter, Tabellen & Abb.)

1960/61 **625** .212
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 295.
MÖSKEN (K.). — **Verschleissmindernde Massnahmen an Radreifen von Schienenfahrzeugen** und ihre Auswirkungen auf den Schienenverschleiss. (4 000 Wörter & Abb.)

1960/61 **621** .39
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 313.
WITTING (R.) und WINKLER (G.). — Ein Beitrag zur **Entwicklung von Lokomotivantennen im UKW-Gebiet für Rangier- und Streckenfunkdienste** der Deutschen Reichsbahn. (2 500 Wörter & Abb.)

1960/61 **691**
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 359.
CONRAD (D.). — **Wovon hängt die Betonfestigkeit ab ?** (1 800 Wörter & Abb.)

1960/61 **721** .
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 373.
BIENERT (G.) und SCHMIDT (G.). — Beitrag zu **Ermittlung von Tragreserven in massiven Gewölbebrücken** *Teil I*: Modellstatische Ermittlung der durch Mitwirkung der Aufbauten reduzierten Verkehrslastspannungen in einem Einzelgewölbe. (3 500 Wörter, Tafel & Abb.)

1960/61 **385** (09 .3 (43
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 415.
REHBEIN (E.). — **125 Jahre deutsche Eisenbahn** (7 000 Wörter & Abb.)

1960/61 **656** .2
Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Heft 2, S. 447.
WIDERSTEIN (K.). — **Methoden der Preisdifferenzierung bei der Gütertarifbildung.** (7 000 Wörter.)

In English.

Electric Traction on the Railways. (Brussels.

1961 **621** .33 (42
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 7 July, p. 303.
CALVERLEY (H.B.) and GRAHAM (G.W.). — Development in **50 c/s traction.** (2 400 words & figs

---

1961 **621** .431 .72 (4
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 7 July, p. 317.
FLETY and BOISSON. — The series 040 DG **Diesel electric locomotives** of the S.N.C.F. (4 400 words & figs

---

1961 **621** .31
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 7 July, p. 335.
BALKOW (J.), LÖWEL (H.) and REITWIESSNE (F.). — Controlled **silicon rectifiers.** (1 800 words & figs

---

1961 **621** .33
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 7 July, p. 341.
LUCAS (H.W.). — Electro-pneumatic **contactors f traction.** (1 500 words & figs.)

1961 **625** .28
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. July, p. 348.
ZIEBART (E.). — A high capacity test bench f locomotive gears. (1 450 words & figs.)

The Chartered Mechanical Engineer. (London.)

1961 **621** .89
The Chartered Mechanical Engineer, September, p. 414.
ROWE (G.W.). — **Friction and progress.** (3 000 words & figs.)

Reports, Association of American Railroads. (Chicago.)

1961 **385** (061 .4 (73)
Advance Reports, Association of American Railroads, First Annual Meeting, Communication and Signal Section, Toronto, Ontario, October 2, 3 and 4, 1961. (392 pages, illustrated.)

The Engineer. (London.)

1961 **625** .172
The Engineer, August, 4, p. 200.
150-Ton Diesel railway breakdown crane. (800 words & figs.)

1961 **621** .133 .1
The Engineer, August, 11, p. 239.
Tests on an « Austerity » locomotive fitted with a mechanical stoker. (1 100 words & figs.)

1961 **621** .132 .1 (44)
The Engineer, August, 18, p. 262.
LIVESAY (E.H.). — **The Compound locomotive in France.** (9 000 words & figs.)

1961 **621** .335 (675)
The Engineer, August, 25, p. 344.
Silicon rectifier locomotives for the Congo. (1 600 words & figs.)

Ganz-Mávag Bulletin. (Budapest.)

1961 **625** .28 (01
Ganz-Mávag Bulletin, May, p. 68.
PARKAI (I.). — **Two fundamental factors of railway traction : Resistance and tractive force.** Their computation, research and check measurements. (3 500 words, tables & figs.)

1961 **625** .213
Ganz-Mávag Bulletin, May, p. 88.
DESTEK (M.) and HAUBOS (K.). — **Running quality test of railway vehicles.** (7 000 words & figs.)

Proceedings, The Institution of Civil Engineers. (London.)

1961 **624** .63 (42)
Proceedings, The Institution of Civil Engineers, September, p. 1.
TURTON (F.). — **Three prestressed concrete railway bridges.** (18 pages, illustrated.)

International Railway Journal. (The Hague.)

1961 **621** .337 & **621** .431 .72 (54)
International Railway Journal, July, p. 21.
The Suri-transmission. (1 800 words & figs.)

1961 **385** & **656** .2
International Railway Journal, July, p. 27.
ILO looks at modernization on the rails. (2 500 words & figs.)

1961 **625** .4 (43)
International Railway Journal, July, p. 32.
Hamburg tests the DT 2. (600 words & figs.)

1961 **621** .431 .72
International Railway Journal, July, p. 34.
Germany-Italy-Japan : New concepts in shunters. (2 000 words & figs.)

Modern Railroads. (Chicago.)

1961 **65** (73)
Modern Railroads, July. p. 59.
MYERS (E.T.). — **Rio Grande's data revolution. — I, II-III.** (9 400 words & figs.)

1961 **656** .212 .5 (73)
Modern Railroads, July, p. 81.
Test hydraulic yard speed control. (500 words & figs.)

1961 **621** .431 .72 (4)
Modern Railroads, September, p. 91.
REED (B.). — **Why Europe turns to Diesel hydraulics.** (2 500 words & figs.)

1961 **621** .431 .72 (73)
Modern Railroads, September, p. 98.
Diesel hydraulics are coming. (1 500 words & figs.)

Modern Transport. (London.)

1961 **625** .253 (42)
Modern Transport, July 1, p. 3.
Disc-braked railway wagons. (1 400 words & figs.)

1961 **621** .335 (44)
Modern Transport, July 1, p. 13.
Dual current electric locomotive performance. (900 words & figs.)

1961 **621** .338 (42)
Modern Transport, July 8, p. 6.
Metropolitan line re-equipment. — Dual-purpose rolling stock (*continued*). (500 words & figs.)

1961 **621** .431 .72 (42) & **625** .282 (42)
Modern Transport, July 8, p. 12; July 15, p. 12.
Eastern Region Type 3 Diesel. (1 800 words & figs.)

Railway Age. (New York.)

1960 **625** .232 (73)
Railway Age, October 3, p. 16.
Convair shows transit design. (500 words & figs.)

1960 **385** .13 & **657** (73)
Railway Age, October 3, p. 18.
PRR mechanizes property tax accounting. (900 words & figs.)

1960 **621** .32 (73)
Railway Age, October 3, p. 24.
How UP lights repair track. (350 words & figs.)

1960 **656** .225 & **656** .235 .1 (73)
Railway Age, October 17, p. 9.
Fourth morning coast-to-coast. (450 words.)

1960 **62** (71 (73)
Railway Age, October 17, p. 13.
Rail automation : here, now. (1 000 words.)

1960 **656** .2
Railway Age, October 17, p. 18.
Rail transit : what's ahead ? (1 200 words.)

1960 **656** .254
Railway Age, October 17, p. 25.
Radio controls GE switcher. (350 words & figs.)

1960 **62** & **656** .22 (73)
Railway Age, October 17, p. 26.
New York has automatic train. (500 words & figs.)

1960 **385** (73)
Railway Age, November 28, p. 9.
ICC gets New Haven relief plan. (1 000 words.)

1960 **656** .1 & **656** .225 (73)
Railway Age, November 28, p. 17.
Shippers support « one-plan » TOFC. (700 words.)

1960 **656** .1 & **656** .225 (73)
Railway Age, November 28, p. 22.
TOFC traffic, revenues reach new highs as autos roll by rail. (1 700 words & figs.)

1960 **656** .1 & **656** .225 (73)
Railway Age, November 28, p. 38.
Why GSC turns to piggyback. (700 words & figs.)

1960 **624** .32 (73)
Railway Age, November 28, p. 58.
New bridge clears river traffic. (1 000 words & figs.)

1960 **656** .225 (73)
Railway Age, November 28, p. 65.
T & P builds special auto-ramps. (400 words & figs.)

1960 **656** .1 & **656** .225 (73)
Railway Age, December 19/26, p. 9.
REA plans TOFC trailer pool. (450 words.)

1960 **656** & **658** .16 (73)
Railway Age, December 19/26, p. 10.
C & O claims victory in B & O contest. (450 words.)

1960 **656** .225 (73)
Railway Age, December 19/26, p. 18.
How RRs fight lading damage. (950 words & figs.)

1960 **385** & **656** .225 (73)
Railway Age, December 19/26, p. 38.
CN takes analytical approach to loss and damage prevention. (1 200 words.)

1961 **385** (73)
Railway Age, January 9, p. 7.
Doyle asks transport changes. (1 800 words.)

1961 **656** .231 (73)
Railway Age, January 9, p. 9.
ICC lets differentials stand. (350 words.)

1961 **656** .254
Railway Age, January 9, p. 11.
What's wrong with railroad TV ? (400 words.)

1961 **656** .254
Railway Age, January 9, p. 14.
Mc KNIGHT (R.W.). — **Radio can save you time and money.** (1 000 words.)

1961 **625** .24 & **656** .23 (73)
Railway Age, January 9, p. 18.
PRR plans for traffic upturn. (700 words & figs.)

1961 **621** .37 (73)
Railway Age, February 6, p. 13.
Frisco has big microwave plans. (300 words & figs.)

Railway Engineering. (Cape Town.)

1961 **625** .233
Railway Engineering, August, p. 22.
The development of lighting in railway coaches. (2 000 words & figs.)

1961 **625** .144 & **625** .172
Railway Engineering, August, p. 27.
Many new methods and machines for improving the permanent way. (1 500 words & figs.)

1961 **625** .144 & **625** .172
Railway Engineering, August, p. 35.
Plasser machines assist South African Railways. (1 100 words & figs.)

1961 **625** .172
Railway Engineering, August, p. 38.
Developments in the use of Kango portable electric ballast tampers. (450 words & figs.)

1961 **625** .144 & **625** .172
Railway Engineering, August, p. 39.
British loco builders make ballast cleaning machine. (250 words & figs.)

The Railway Gazette. (London.)

1961 656 .25 (42)
The Railway Gazette, July 28, p. 98.
GREEN (R.A.). — **Signalling and telecommunications in the Eastern Region.** (1 800 words & figs.)

1961 625 .282 (42)
The Railway Gazette, July 28, p. 102.
Two-power locomotives for British Railways. (400 words & figs.)

1961 625 .234 (42)
The Railway Gazette, July 28, p. 103.
Oil fuel combustion heaters on British Railways. (400 words & figs.)

1961 621 .33 (47)
The Railway Gazette, July 28, p. 106.
Railway electrification in the U.S.S.R. (800 words & figs.)

1961 621 .33
The Railway Gazette, July 28, p. 108.
Electric sets for Trans-Europe express trains. (700 words & figs.)

1961 656 .25 (42)
The Railway Gazette, August 4, p. 129.
HANSTOCK (P.W.). — **Microwave radio-telephone in the North Eastern Region.** (2 200 words & figs.)

1961 625 .162 (42)
The Railway Gazette, August 4, p. 137.
Lifting barriers at Barton Street in the Western Region. (600 words & figs.)

1961 625 .25
The Railway Gazette, August 11, p. 157.
Modernised vacuum-brake equipment. (900 words & figs.)

1961 625 .282 (42)
The Railway Gazette, August 11, p. 159.
Type 5 locomotive for British Railways. (1 000 words & figs.)

1961 625 .215
The Railway Gazette, August 25, p. 216.
KOFFMAN (J.L.). — **Carriage and railcar bogies their design and development.** — IV (*concluded*). (1 100 words & figs.)

1961 656 .25 (44)
The Railway Gazette, August 25, p. 223.
Signalling on the Dijon-Vallorbe line of the S.N.C.F. (1 300 words & figs.)

1961 656 .212 .5 (941)
The Railway Gazette, September 1, p. 247.
Interchange marshalling yard at Leighton, Western Australia. (650 words.)

1961 625 .232 (42)
The Railway Gazette, September 1, p. 249.
Pullman cars for British Railways, North Eastern Region. (550 words & figs.)

Diesel Railway Traction. (London.)

1961 625 .234
Diesel Railway Traction, July, p. 256.
Small heaters for railcars. (900 words & figs.)

1961 621 .337
Diesel Railway Traction, July, p. 257.
Hydraulic individual axle drive. (3 000 words & figs.)

1961 621 .431 .72 (42)
Diesel Railway Traction, July, p. 271.
Brush locomotives of British Railways. (3 000 words & figs.)

1961 625 .282 (42)
Diesel Railway Traction, August, p. 291.
Type 3 Diesel-hydraulic locomotives. (1 000 words & figs.)

1961 625 .282 (73)
Diesel Railway Traction, August, p. 295.
4 000 HP locomotive units for U.S.A. (6 000 words & figs.)

Railway Locomotives and Cars. (New York.)

1961 656 .25
Railway Locomotives and Cars, March, p. 31.
AYDELOTT (J.C.). — **Brake application limit wheel slip.** (2 000 words & figs.)

1961 625 .232 (73)
Railway Locomotives and Cars, March, p. 40.
Milwaukee puts stainless-steel cars in commuter service. (400 words & figs.)

1961 621 .333
Railway Locomotives and Cars, March, p. 44.
Developing traction-motor insulation (*to be continued*). (1 600 words & figs.)

1961 621 .431 .72 (73)
Railway Locomotives and Cars, August, p. 15.
Rio Grande measures ring wear. (1 900 words & figs.)

1961 625 .245 (73)
Railway Locomotives and Cars, August, p. 21.
Unusual tank gives high capacity. (400 words & figs.)

Railway Signalling and Communications. (New York.)

1961 656 .25 (73)
Railway Signalling and Communications, August, p. 15.
Santa Fe signals new main line. (1 400 words & figs.)

1961 656 .25 (73)
Railway Signalling and Communications, August, p. 20.
Digital computer simulated CTC dispatcher. (900 words & figs.)

In Italian.

Giornale del Genio Civile. (Roma.)

1961 **624** .6
Giornale del Genio Civile, luglio-agosto, p. 634.
PAGANO (M.) & SANNINO (R.). — Contributo teorico-sperimentale al **problema dell'instabilità delle volte travi.** (*Continua.*) (7 000 parole, tavole & fig.)

Politica dei Trasporti. (Roma.)

1961 **385** (45)
Politica dei Trasporti, luglio-agosto, p. 319.
PINTO (G.). — Il bilancio dei trasporti e la **relazione della Commissione di esperti sulla situazione delle F.S.** (4 500 parole & tavole.)

Rivista di Ingegneria. (Milano.)

1961 **621** .38
Rivista di Ingegneria, agosto, p. 821.
CALIGIURI (G.P.). — **I transistors come elementi operazionali nella tecnica del calcolo analogico.** (3 000 parole & fig.)

1961 **621** .89
Rivista di Ingegneria, agosto, p. 837.
LENTI (F.) & MOSCONE (G.). — **Problemi di lubrificazione** dei motori a due tempi a benzina. (1 500 parole & fig.)

In Netherlands.

De Ingenieur. (Den Haag.)

1961 **624** .8 (492)
De Ingenieur, nr 33, 18 augustus, p. B. 141.
VAN SCHRAVENDIJK (J.F.). — **Het onderzoek naar het bezwijken van de basculebrug** over de Parksluizen te Rotterdam. (1 500 woorden & fig.)

1961 **625** .4
De Ingenieur, nr 33, 18 augustus, p. V. 50.
Personensnelverkeer in grote bevolkingscentra. (1 500 woorden & fig.)

1961 **621** .338 (45)
De Ingenieur, nr 33, 18 augustus, p. V. 53.
Nieuwe elektrische vierwagentreinen eerste klasse van de Italiaansche Staatsspoorwegen. (300 woorden & fig.)

1961 **621** .31
De Ingenieur, nr 34, 25 augustus, p. E. 67.
DE JONG (H.C.J.) en WIJNTERP (W.). — **Meting van de spanningdeuk van draaistroomgeneratoren** bij plotselinge belastingtoename. (3 000 woorden & fig.)

1961 **691**
De Ingenieur, nr 34, 25 augustus, p. Bt. 102.
PAUW (A.). — **The present status of structural lightweight concrete** in the U.S.A. (5 000 woorden & fig.)

1961 **669** .1 (06
De Ingenieur, nr 35, 1 september, p. B. 153.
XXe Internationaal Staalcongres, gehouden van 29-31 mei 1961 te Milaan. (2 000 woorden.)

1961 **62** (01
De Ingenieur, nr 35, 1 september, p. W. 123.
DE PATER (C.). — **Thermal stresses in tube plates.** (2 500 woorden & fig.)

Spoor- en Tramwegen. (Den Haag.)

1961 **656** .225 (492)
Spoor- en Tramwegen, nr 16, 10 augustus, p. 257.
VAN NIMWEGEN (F.A.J.). — **Marktonderzoek voor het goederenvervoer bij N.S.** (2 500 woorden.)

1961 **656** .254
Spoor- en Tramwegen, nr 16, 10 augustus, p. 260.
VAN ALBADA (N.B.). — **Automatisatie van het werk van de dispatcher,** door A.A. EILER en B. ZAVJALOV. (Russisch tijdschrift « Spoorwegtransport », april 1961. (*Samenvatting.*) (1 200 woorden & fig.)

1961 **625** .232 (4
Spoor- en Tramwegen, nr 16, 10 augustus, p. 261.
WEEMAELS (F.). — De **Internationale Maatschappij van de Slaapwagens** en de Grote Europese Expressen. (2 000 woorden & fig.)

1961 **385** (09 (73
Spoor- en Tramwegen, nr 16, 10 augustus, p. 264.
STUNNENBERG (J.). — De **Pennsylvania Railroad Company.** (1 500 woorden & tabellen.)

1961 **625** .
Spoor- en Tramwegen, nr 16, 10 augustus, p. 269.
VAN WIJCK JURRIAANSE. — Nog iets over **twee- en drieassig materieel.** (900 woorden.)

1961 **656** .222 .6 (4
Spoor- en Tramwegen, nr 17, 24 augustus, p. 273.
KORSWAGEN (J.W.). — **TEEM** — **Het ontstaan van het TEEM-net** in de internationale goederentreindienst. (2 000 woorden & fig.)

1961 **625** .1
Spoor- en Tramwegen, nr 17, 24 augustus, p. 277.
HAUER (J.M.). — **Internationale samenwerking op het gebied van het wegonderhoud.** (800 woorden & fig.)

1961 **656** .2 (41
Spoor- en Tramwegen, nr 17, 24 augustus, p. 278.
Reorganisatie van de Ierse Spoorwegen. (1 200 woorden & fig.)

1961 **656** .2 (497 .2
Spoor- en Tramwegen, nr 17, 24 augustus, p. 280.
STUNNENBERG (J.). — **Georgi Dimitrov leeft nog.** (2 000 woorden, tabellen & fig.)

In Portuguese.

Boletim da C.P. (Lisboa.)

1961 **725** .33 (469)
Boletim da C.P., nº 386, agosto, p. 9.
AMORIM (O.) & CAMEIRA (P.). — **A construção das novas oficinas Diesel-eléctricas no Entroncamento.** Fiscalização das obras. (*Continua.*) (1 000 palavras & fig.)

Gazeta dos Caminhos de Ferro. (Lisboa.)

1961 **656** .2 (06
Gazeta dos Caminhos de Ferro, nº 1769, 1 de Setembro, p. 239.
BUSQUETES DE AGUILAR (M.). — **Relações ferroviárias de carácter internacional.** (2 000 palavras.)

1961 **656** .2 (84)
Gazeta dos Caminhos de Ferro, nº 1770, 16 de Setembro, p. 260.
de BRITO LEAL (C.). — Os Caminhos de ferro nos países longínquos. **A rede ferroviária da Bolivia.** (2 000 palavras & mapa.)

Técnica. (Lisboa.)

1961 **621** .438
Técnica, julho, p. 589.
ADRIÃO DE SEQUEIRA (J.C.). — **Turbinas a gás.** (4 500 palavras, quadros & fig.)

In Polish (= 491 .85).

Przeglad Kolejowy Mechaniczny. (Varsovie.)

1960 **625** .28 (438) = 491 .85
Przeglad Kolejowy Mechaniczny, janvier, p. 1.
MLODECKI (W.). — **Le service de la traction aux P.K.P.** (Chemins de fer de l'Etat polonais) en 1959 et ses tâches principales en 1960. (2 900 mots.)

1960 **625** .2 (438) = 491 .85
Przeglad Kolejowy Mechaniczny, janvier, p. 5.
NEUMANN (T.). — **Le service du matériel roulant aux P.K.P.** en 1959 et 1960. (3 100 mots & fig.)

1960 **625** .212 = 491 .85
Przeglad Kolejowy Mechaniczny, janvier, p. 24.
PIEROZEK (B.). — **La réparation par soudure électrique à la main des bandages de roue endommagés.** (1 200 mots & fig.)

1960 **625** .28 (438) = 491 .85
Przeglad Kolejowy Mechaniczny, février, p. 33.
MLODECKI (W.). — **Progrès technique dans le service de la traction aux P.K.P.** d'après le plan 1961-1965. (2 800 mots & fig.)

1960 **621** .431 .72 = 491 .85
Przeglad Kolejowy Mechaniczny, février, p. 40 (*suite*, nº de mars, p. 69).
WOLFRAM (T.). — **Le moteur Diesel à haute pression et la transmission pour automotrices.** (7 100 mots & fig.)

1960 **625** .213 = 491 .85
Przeglad Kolejowy Mechaniczny, mars, p. 76.
ZIEBA (H.). — **La réparation des ressorts à lames** à la remise à wagons à Leszno. (3 600 mots & fig.)

1960 **621** .436 = 491 .85
Przeglad Kolejowy Mechaniczny, avril, p. 104.
KOWALSKI (E.). — **Suralimentation des moteurs Diesel** (augmentation de la puissance par accroissement de la pression moyenne réelle). (900 mots & fig.)

1960 **625** .245 = 491 .85
Przeglad Kolejowy Mechaniczny, avril, p. 107.
GANDZIAREK (M.). — **Un nouveau type de wagons pour le transport des porcs.** Série Snsh. (1 100 mots & fig.)

1960 **625** .215 = 491 .85
Przeglad Kolejowy Mechaniczny, avril, p. 119.
BALA (Z.). — **Dégâts typiques des bogies de voitures et leurs réparations.** (1 000 mots & fig.)

1960 **614** .8 = 491 .85
Przeglad Kolejowy Mechaniczny, mai, p. 129.
MLODECKI (W.). — **La sécurité du travail dans le service de la traction en 1959.** (2 600 mots.)

1960 **625** .2 (438) = 491 .85
Przeglad Kolejowy Mechaniczny, mai, p. 133.
GANDZIAREK (M.). — **Progrès technique dans le matériel roulant des P.K.P.** en 1961-1965. (2 500 mots.)

1960 **621** .335 (438) = 491 .85
Przeglad Kolejowy Mechaniczny, juin, p. 161.
ZIELINSKI (A.). — **Dispositifs d'homme-mort** dans les locomotives électriques des P.K.P. (1 600 mots & fig.)

1960 **621** .33 (438) = 491 .85
Przeglad Kolejowy Mechaniczny, juin, p. 171.
JÓZWIAK (W.). — **Développement de l'électrification aux P.K.P.** (1 100 mots & fig.)

1960 **625** .24 = 491 .85
Przeglad Kolejowy Mechaniczny, juin, p. 173.
UCIESZYŃSKI (J.). — **Révisions périodiques des wagons dans les remises.** (2 100 mots.)

1960 **625** .245 = 491 .85
Przeglad Kolejowy Mechaniczny, juin, p. 176.
LEWANDOWSKI (W.). — **Nouveau wagon-citerne** pour le transport de l'anhydride carbonique liquide. (2 000 mots & fig.)

1960 **625** .248 = 491 .85
Przeglad Kolejowy Mechaniczny, juin, p. 181.
KIELKIEWICZ (W.). — **Désinfection des wagons.** (1 500 mots & fig.)

Przeglad Kolejowy Przewozowy. (Varsovie.)

1960 **656** .21 (438) = 491 .85
Przeglad Kolejowy Przewozowy, janvier, p. 2.
ZAJFRYD (M.). — **Résultats du travail du service d'exploitation aux P.K.P.** (2 800 mots & tableaux.)

1960 **656** (438) = 491 .85
Przeglad Kolejowy Przewozowy, février, p. 36.
OMELIANIUK (S.). — **Pologne — pays de transit.** (3 100 mots & fig.)

1960 **625** .28 = 491 .85
Przeglad Kolejowy Przewozowy, mars, p. 66.
MLODECKI (W.). — **Mieux exploiter les moyens de traction !** (3 200 mots & tableaux.)

1960 **656** .225 = 491 .85
Przeglad Kolejowy Przewozowy, mars, p. 74.
Rationalisation des transports sidérurgiques. (1 200 mots.)

1960 **656** .212 = 491 .85
Przeglad Kolejowy Przewozowy, mars, p. 76.
KOSMIDER (J.). — **L'observation des principes d'exploitation constatée dans les manœuvres.** (1 000 mots.)

1960 **656** .2 = 491 .85
Przeglad Kolejowy Przewozowy, avril, p. 99 (*suite*, mai, p. 122.)
PIELAS (C.). — **Procédés technologiques rapides.** (2 400 mots & fig.)

1960 **656** .225 = 491 .85
Przeglad Kolejowy Przewozowy, avril, p. 101.
ROSZAK (T.). **Le transport des envois dans des containers universels.** (2 100 mots & tableaux.)

1960 **621** .431 .72 (438) = 491 .85
Przeglad Kolejowy Przewozowy, avril, p. 105.
KOWALSKI (E.). — **Le matériel roulant Diesel aux P.K.P.** (2 200 mots & fig.)

1960 **656** .28 (438) = 491 .85
Przeglad Kolejowy Przewozowy, mai, p. 114.
GRYZEL (I.). — **Avaries accidentelles aux P.K.P. en 1959.** (1 900 mots, tableaux & fig.)

1960 **625** .282 = 491 .85
Przeglad Kolejowy Przewozowy, mai, p. 124.
SZKÓP (Z.). — **Les avantages économiques résultant de l'emploi des locomotives Diesel dans les manœuvres.** (2 400 mots.)

1960 **656** .2 = 491 .85
Przeglad Kolejowy Przewozowy, juin, p. 161.
ZABOROWSKI (M.) et KRYNICKI (J.). — **La régularité du trafic des trains.** (2 300 mots.)

In Russian (+ German and Chinese) (= 491 .7).

Bulletin de l'OSJD. (Varsovie.)

1960 **656** .2 (517) = 491 .7
Bulletin de l'OSJD, n° 1, p. 3.
LEGDEN DAMDINDHAW. — **La planification des transports aux Chemins de fer de Mongolie.** (1 300 mots.)

1960 **656** .21 (51) = 491 .7
Bulletin de l'OSJD, n° 1, p. 5.
HUAN DO. — **Performances du service d'exploitation des Chemins de fer Chinois.** (2 100 mots.)

1960 **656** .1 = 491 .7
Bulletin de l'OSJD, n° 1, p. 8.
ASSANOWICZ (B.M.) et DAWYDOW (W.M.). — **Recherche scientifique concernant le transport par automobiles et le service routier.** (1 500 mots.)

1960 **656** .225 = 491 .7
Bulletin de l'OSJD, n° 1, p. 11.
HOFMANN (K.). — **Containers déformables pour le transport des matières liquides et pulvérulentes.** (1 400 mots.)

1960 **621** .335 = 491 .7
Bulletin de l'OSJD, n° 1, p. 13.
SAMOKHVALOV (A.W.). — **Le choix des locomotives électriques à courant alternatif et des installations de traction électrique.** (2 200 mots & tableaux.)

1960 **656** .223 .2 = 491 .7
Bulletin de l'OSJD, n° 2, p. 1.
ROBEL (R.I.). — **L'accroissement des transports** exige l'emploi de méthodes plus perfectionnées d'exploitation des wagons. (1 200 mots.)

1960 **656** .2 (51) = 491 .7
Bulletin de l'OSJD, n° 2, p. 3.
MAO I-CHEN et TCHAI MO. — **Dix années de développement de la science et de la technique** du transport ferroviaire dans la République Populaire de Chine. (3 900 mots.)

1960 **625** .235 = 491 .7
Bulletin de l'OSJD, n° 2, p. 9.
ALBEGOV (N.). — **Les freins électropneumatiques** pour les voitures et les wagons. (1 700 mots & fig.)

1960 **656** .2 (06 = 491 .7
Bulletin de l'OSJD, n° 2, p. 12.
REŽABEK (J.). — **La collaboration de l'OSJD avec les autres Organisations internationales de transport.** (1 200 mots.)

1960 **625** .252 = 491 .7
Bulletin de l'OSJD, n° 2, p. 14.
SEREDINE (A.). — **Sabots de frein non-métalliques pour le matériel roulant.** (600 mots.)

1960 625 .285 = 491 .7
Bulletin de l'OSJD, n° 3, p. 1.
KALININE (S.S.). — **L'unification du matériel-autorails** et la spécialisation de la production de celui-ci. (1 800 mots.)

1960 625 .24 = 491 .7
Bulletin de l'OSJD, n° 3, p. 4.
GÜTTER (R.). — Mesures efficaces pour réduire la **tare des wagons.** (2 300 mots & fig.)

1960 625 .17 = 491 .7
Bulletin de l'OSJD, n° 3, p. 8.
U TCHEN-SAN et GÄRTNER (C.). — **Petite mécanisation des travaux à la superstructure.** (1 700 mots & fig.)

1960 656 .2 (06 = 491 .7
Bulletin de l'OSJD, n° 3, p. 15.
OLŠAR (V.). — **Création d'un système d'informations d'ordres technique et économique** entre les chemins de fer participants de l'OSJD. (1 800 mots.)

1960 656 .222 .5 = 491 .7
Bulletin de l'OSJD, n° 3, p. 11.
KHAN LI-PIN. — **Des améliorations en service voyageurs international** (« SMPS »). (1 200 mots.)

1960 621 .332 = 491 .7
Bulletin de l'OSJD, n° 3, p. 13.
TIMOCHENKOV (I.T.). — **L'alimentation électrique des trains de voyageurs,** un problème actuel. (1 700 mots.)

1960 347 .763 = 491 .7
Bulletin de l'OSJD, n° 3, p. 16.
GÓRSKI (W.). — **Définition du droit de transport.** (2 200 mots.)

In Swedish (= 439 .71).

Järnvägs - Teknik. (Stockholm.)

1961 385 .523 = 439 .71
Järnvägs-Teknik, n° 5, p. 103.
SVANTESSON (G.). — **Système de salaire aux pièces pour ateliers d'entretien.** (2 000 mots & fig.)

1961 656 .222 .1 = 439 .71
Järnvägs-Teknik, n° 5, p. 106.
RYDBERG (G.). — **Vitesses de voyage sur les chemins de fer pendant l'été 1961.** (1 700 mots.)

M. Weissenbruch & Co., Ltd., Printer to the King, 40, rue de l'Orphelinat, Bruxelles 7.

PRINTED IN BELGIUM

M. WEISSENBRUCH & Co. Ltd.
Printer to the King
(Manag. Dir. : P. de Weissenbruch,
238, chaussée de Vleurgat, XL)
Edit. responsible : P. Ghilain